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PRIMITIVE TREPHINING IN PERU

BY

MANUEL ANTONIO MUNIZ, M. D.,

AND

W. J. MCGEE

1894-95

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## PREFATORY NOTE

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During several years prior to 1893, Dr Manuel Antonio Muñiz, some time Surgeon-General of the Army of Peru, traveled extensively through the ancient land of the Incas, and made large collections from the huacals and scattered graves of the Andean valleys and the desiccated Piedmont zone inclining from the Cordillera toward Pacific ocean. Lowland Peru is arid, and even the rugged highlands fronting the Pacific receive but limited rainfall; and by reason of a combination of conditions the air and so the soil are dry nearly all the year, and in some places the ground is saline or nitrous. Accordingly organic matter buried in the earth is preserved in a manner hardly conceivable to those accustomed to the conditions of humid lands; and thus Dr Muñiz' explorations were remarkably fruitful.

The material collected from the long-neglected tombs of Peru by Dr Muñiz comprised weapons of war and the chase, implements in wide variety, domestic utensils, costumery of skins and stuffs, and articles of adornment, all in considerable quantity; though his tastes and training led him to devote especial attention to the somatic remains of the ancient people. His collection comprised something over a thousand crania; of these, nineteen were found to be trephined, several more than once.

In 1893 Dr Muñiz attended the "International Congress of Anthropology of the World's Congress Auxiliary of the World's Columbian Exposition" at Chicago, for the purpose of exhibiting and describing the trephined crania. His formal communication, translated into English, forms the accompanying "summary statement." Afterward he attended the Pan-American Medical Congress at Washington, and exhibited the collection informally; and still later he transferred its custody to the writer, on behalf of the Bureau of American Ethnology, for use in preparing the accompanying description of the remarkably interesting series of specimens of primitive surgery.

On his return to Lima, toward the end of 1893, Dr Muñiz had the misfortune to encounter a political movement; before it ended his house was sacked and burned, his library and his rich collections were destroyed, and he was exiled. Of all of the archeologic material brought together during his years of labor, only the collection of trephined crania remains; and the energetic collector has insured the safety of this remnant by



transferring it to the Bureau of American Ethnology for preservation in the United States National Museum, save for a single specimen (the triple-trephined cranium, from Cuzco) which has been placed in the United States Army Medical Museum.

The Muñiz crania have been examined by many scientific and medical men in the United States; since they were brought before the World's Congress at Chicago and the members of the Pan-American Congress at Washington, they have been exhibited and discussed before the Anthropological Society of Washington, the Archeological Association of Philadelphia, the Medical Society of the District of Columbia, Washington, and the Historical Club of Johns Hopkins Hospital, Baltimore; and in addition they have been inspected by many visitors to the Bureau. The accompanying description has been prepared in the light of much discussion concerning the collection, and is framed to answer, so far as may be, the principal inquiries made by students. As originally made, the collection of trephined crania was supplemented and illumined by the collateral objects representing the arts of the primitive trephiners; but since the remainder of the collection is, unhappily, lost irretrievably, it has been deemed desirable so to extend the description and discussion of the crania and the details of the operation as to render the series self-explanatory in every respect. It may, however, be noted that the inferences as to methods and motives are in precise accord with the testimony of associated objects. For purposes of comparison, illustrations of the "Inca skull" brought from Peru by the late E. G. Squier, and of eight trephined crania preserved in the Municipal Museum at Cuzco, are introduced. A more exhaustive discussion of primitive trephining in Peru by Dr Muñiz may be looked for in the future.

For the arduous duty of making the collection and establishing the authenticity of the specimens through careful study of associations, and for the accompanying summary statement, Dr Muñiz deserves the credit and bears the responsibility; for the remaining portion of the paper and for the fidelity of the illustrations the writer is responsible. The respective authorial responsibility is indicated specifically by initials in the list of contents and in the principal subtitles.

W J M.

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# PRIMITIVE TREPHINING IN PERU

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BY MANUEL ANTONIO MUÑIZ, M. D., AND W J MCGEE

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## SUMMARY STATEMENT

(M. A. M.)

Much has been written on prehistoric trephining, and it is a well-understood fact that in the ancient villages of this and of the Old World, and even in some of the settlements of the present savages, trephining has been known and practiced, not only for religious purposes but also for surgical purposes, to effect a cure of disorders consequent on traumatic lesions of the cranium and also as a means of treating certain cerebral diseases.

Therefore the historico-bibliographic matters with which every archeologist is perfectly well acquainted may be omitted.

If we take into account the class of offensive weapons used by the ancient Peruvians in their terrible conflicts, almost hand to hand, it will easily be comprehended that complex fracture of the skull with depression of its bony plates must have been very common. In fact, they were accustomed to throw stones of more or less round or irregular shape to great distances with high initial velocity by means of the sling; they were also armed with large wooden clubs, extremely hard, in the ends of which splints of copper or stone were fastened, as well as hatchets of both these materials and of diverse forms.

Without treating of the order in which the different civilizations of ancient Peru were developed and gained predominance, it may only be observed that it is certain the aborigines possessed advanced medical knowledge, making use of a magnificent flora, full today of secrets to us. They knew how to reduce luxation effectively, and employed fixation to consolidate fractures, sometimes having recourse in both cases to kneading (massage); they knew the dangers of free exposure of wounds to the air, curing these very thoroughly; they could easily distinguish syphilis, rheumatism, ague, fevers, cerebral disturbance, mental aberration, etc. Fragments of flint sharpened to a point were used for bleeding and excising pterygiums, and the same sharpened on the



edge for cutting the umbilical cord. Lastly, they possessed a perfect process of mummification. It does not therefore seem strange, surgical science being so advanced in prehistoric Peru, that on the presentation of a broken skull they should attempt first to extract the fragments of bone, to raise and draw out successively the sunken plates, to adjust the points, and, in a word, with their primitive instruments, as primitive as those of ancient Greece and Persia, to accomplish the linear readjustment of the edges of the fracture, forming a quadrangular or polygonal orifice. After this they could easily make the orifice circular or ellipsoidal, etc, by means of strong chisels or *estiletes* of copper, silver, gold, or *champi* (a mixture of gold, silver, and copper, the only metals known to them); also an instrument called *tumi*, which consisted of a blade, straight or curved like a crescent, edged and furnished with a short central haft in the form of a T, together with knives and lances of obsidian.

It would be an extensive undertaking to attempt an analysis of this subject, and, indeed, the last works of Fletcher, Mantegazza, Mason, Wyman, and Munro have saved me the task.

Now, at first sight, or by examination with the lens, it is possible to distinguish cranial perforations due to a pathologic operation from those which have been made artificially. The difference is obvious and very clear. But it has been supposed that when they were not pathologic perforations they were post-mortem operations. I repeat, it is not difficult to know whether the bone has been separated while the individual was living and whether he survived the operation; the length of time could even be determined approximately. There are histologic features which a lens discloses and which will prove without a shadow of doubt the survival of the individual. Moreover, the exaggerated veneration of the ancient Peruvians for their dead completely disproves the supposition, which has been advanced in regard to some other countries or peoples, that trephining was performed only for the purpose of procuring amulets consisting of segments of bone extracted after death from persons noted for valor, intelligence, or virtue. This profanation, if we may so call it, of the bodies of the dead was impossible in ancient Peru, and this fact is proved, since to this day there has never been found any fragment of human bone which could have been used as an amulet.

While forming my collection of ancient crania, seeking them in the various provinces of Peru, I have succeeded in making the collection of trephined crania illustrated in the accompanying plates. I have not attempted for the present to make a craniometric study of them, and take into consideration only the different forms of trephining employed, some of which have not been recognized up to the present time in publications on this subject.

The well-known cranium of Squier was found in the valley of Yucay, near Cuzco, and in the districts adjoining this city, the metropolis of the ancient Inca empire, were found those numbered 7, 10, 12, 13, and 18 in

the accompanying description, which demonstrate the fact that in these localities trephining was not exclusively of the square form, but that other forms also were employed.

In the environs of Lima, more than a thousand miles from Cuzco, I discovered crania 1, 2, 4, 5, 6, 8, 9, 14, 15, 16, and 19, within a radius of 60 miles, in the province of Huarochiri, which is covered with pre-Columbian ruins.

The cranium numbered 17 was discovered in Tarma, in the central part of Peru; cranium 11 in the important ruins of Pachacamac in the neighborhood of the ocean, 15 miles south of Lima. Cranium 3 was found in the ruins of Cañete.

I should observe that up to the present time no trephined crania have been discovered at the famous necropolis of Ancon.

All these skulls, some taken from caves, pertain to a period at least two hundred years anterior to the discovery by Columbus.

#### *Résumé*

1. Trephining as a surgical operation was employed in pre-Columbian Peru in various pueblos and at divers latitudes.

2. Different methods of operation were employed as the segments extracted were of different shapes—square, polygonal, circular, oval, etc.

3. There are found crania which show that the individual succumbed immediately or a short time after the completion of the operation; others are found which indisputably prove the survival of the person subjected to the operation.

4. It is almost impossible to accept for ancient Peru the idea of post-mortem trephining, the numerous other examples of cranial perforation being probably of pathologic origin.



## DESCRIPTION AND DISCUSSION OF THE PERUVIAN CRANIA

(W. J. M.)

### THE COLLECTION

The Muñiz collection comprises 19 trephined crania out of a little over 1,000 specimens; i. e., almost exactly 2 percent of the crania of the collection were trephined. Neglecting a few doubtful cases of repetition, three specimens display two and a third three distinct operations performed at different periods and generally on different parts of the cranium. There are thus twenty-four clear cases of trephining out of 1,000 specimens, or a percentage of about 2.5.

Two of the crania are fragmentary; the other 17 nearly or quite entire. Four were mummified so completely that the desiccated soft tissue remains, despite accidents of exhumation and transportation; most of the others were mummified also, though the tissues have now disappeared; in two or three cases the bone was bleached, and in two others deeply corroded, when found. Most of the thousand skeletons, including those yielding the trephined crania, were exhumed from light and dry sandy, and often nitrous, soil; others were found in caves and rock shelters or on the surface of the ground.

Classed geographically, eleven of the trephined specimens were found in the province of Huarochiri, chiefly in the environs of Lima; one specimen was found in Tarma, another in Pachacamac, not far from Lima, and still another in the province of Cañete; these fourteen specimens representing western central Peru and the more arid piedmont and coastal region. Five specimens were found in the vicinity of Cuzco, in the southeastern and highly mountainous part of the country.

Arranged in the order of description, which in the main is that suggested by character of operation, the crania are as follows:

1. Semimummified cranium from Huarochiri; operation by rectilinear incision (plates I, II).

2. Semimummified cranium from Huarochiri; operation by rectilinear incision (plates IV, V).

3. Weathered cranium from Cañete; operation by rectilinear incision (plates VI, VII).

4. Bleached cranium from Huarochiri; operation by compound rectilinear incision (plates VIII, IX).



5. Semimummified cranium from Huarochiri; operation by multiple rectilinear incision (plates X, XI).

6. Fragmentary cranium from Huarochiri; operation by curvilinear incision (plate XII).

7. Bleached cranium from Cuzco; two operations by curvilinear incision (plates XIII–XV).

8. Fragmentary cranium from Huarochiri; operation by circular incision (plate XVI).

9. Slightly bleached cranium from Huarochiri; operation by curvilinear incision and rasping (plates XVII, XVIII).

10. Ocher-stained cranium from Cuzco; operation by rasping or scraping (plates XIX, XX).

11. Bleached (distorted) cranium from Pachacamac; operation by curvilinear incision and rasping (plates XXI, XXII).

12. Semimummified cranium from Cuzco; two operations, by curvilinear incision and scraping, respectively (plates XXIII, XXIV).

13. Weathered cranium from Cuzco; two operations, by (?) curvilinear incision and rasping (plate XXV).

14. Mummified cranium from Huarochiri; unfinished operation by compound incision (plates XXVIII, XXIX).

15. Mummified cranium from Huarochiri; unfinished operation by compound incision and elevation (plates XXX–XXXII).

16. Mummified cranium from Huarochiri; unfinished operations, by rectilinear incision and by rasping (plates XXXIII, XXXIV).

17. Mummified cranium from Tarma; operation by rasping, with incomplete operations by incision (plates XXXV, XXXVI).

18. Semimummified cranium from Cuzco; three operations, by (?) curvilinear incision and rasping (plates XXXVII, XXXVIII).

19. Semimummified cranium from Huarochiri; operation by incision and rasping, supplemented by plate (plates XXXIX, XL).

The crania are represented on the plates indicated by photo-mechanical (half-tone) reproductions from photographs, mostly by Hillers, with a few by Dinwiddie, on a scale reduced to two-thirds linear of the natural size.

## TREPHINING IN GENERAL

### DISTRIBUTION

Trephining is a fairly common operation in modern surgery. Essentially it consists in the removal of a small section from one of the bones of the skull, usually in the form of a circular button or rondelle. Ordinarily the operation is performed by means of a trephine, or annular saw, supplemented by a few other instruments of simple character, including elevators, stout forceps, etc, together with the usual appliances for making and closing the attendant incisions in the scalp. In some cases the button is restored, either entire or broken up; in other

cases it is replaced by a plate of silver or other substance; sometimes the aperture is left and covered only by the scalp.

The operation is employed in certain cases of depressed fracture or other traumatic lesions of the cranium, and in cases of intra-cranial tumors or suppuration; it is also employed for epilepsy, and more rarely as a prophylactic, or to gain access to the intra-cranial tissues for local treatment.

By most practitioners trephining is regarded as a serious or even desperate operation, and is resorted to only in grave cases. According to Bluhm's statistics, covering nearly 1,000 cases, the mortality exceeds 50 percent, most of the cases being of course complicated by the original lesion. The risk is better determined from the operations for epilepsy without antecedent traumatic conditions; of these cases 16 out of 72 collected by Billings and 28 out of 145 collected by Echeverria, or a mean of 20 percent, proved fatal, though some practitioners, using special precaution against sepsis and avoidable injury to bone and tissues, have obtained better results, one operator recording a mortality so low as 1 out of 30 cases.

Trephining is occasionally employed in the treatment of disorders among domestic animals, though not so much by trained veterinarians as by rude herdsmen possessing little knowledge of anatomy and less of etiology, and imbued with fantastic notions concerning the effect of the operation; e. g., it is performed on sheep and swine with the notion of rupturing a supposed bubble or bladder beneath the skull, or extracting a grub or worm from the brain of the animal, and thus relieving a mysterious disorder. In such cases the operation is commonly performed in rude fashion, perhaps with carpenter's tools, a chisel and mallet, and even an auger being sometimes employed. Not infrequently the animal survives, and in some cases appears to be benefited.

Among certain primitive peoples trephining is practiced, sometimes with astonishing frequency. The Kabyle, a nomadic and essentially autochthonous tribe of Algeria, resort to trephining not only in traumatic lesions of the head, but for neuralgia, vertigo, and various other disorders. The operation is performed rudely, either with such tools or implements as may chance to be at hand, or with crude metallic saws, perforators, and elevators designed for the purpose.<sup>1</sup> Ordinarily the aperture, which is frequently large and usually irregular, is closed by a plate, though it is often left open and covered only by the scalp. The frequency of the operation indicates that the mortality can not be very high, and one observer saw men who had survived five or six operations at different periods and for different injuries. The operator is a hereditary shaman or priest, and the operation is, at least in part, thaumaturgic; the methods are clumsy, painful, and tedious, yet the victim glories in his undemonstrative endurance of the ordeal.

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<sup>1</sup> "On Prehistoric Trephining and Cranial Amulets," by Dr Robert Fletcher, in *Contributions to North American Ethnology*, vol. v, 1882, p. 25 et seq.



Trephining is well known among certain savages. For example, the South Sea islanders were, when first seen by white men, acquainted with the operation, which was performed by scraping with a flint implement, a shark tooth, or (after contact with the whites) a piece of broken glass. The aperture was commonly covered with a carefully prepared piece of cocoanut shell. The purpose was to relieve headache, neuralgia, vertigo, and the like, yet the operation appears to have been essentially thaumaturgic. The mortality has been estimated at 50 percent, yet the treatment is said to have been so common in early days that most of the male adults had undergone one or more operations.

Even in prehistoric times trephining was not uncommon in various parts of the world, as has been shown by Broca, Prunières, and others in Europe, and by Fletcher and some other investigators in this country. While there are indications that the motives varied, satisfactory evidence has been adduced to show that prehistoric trephining, particularly in Europe, was essentially thaumaturgic, and that in many cases the operation was post-mortem and designed to yield rondelles for use as amulets. The instruments used in removing the rondelle were those pertaining to the current cultural stage.

Thus the distribution of trephining with respect to time, territory, and culture-grade shows that the operation is common to several countries and to all stages in the development of mankind from the unwritten past to the present and from savagery to civilization, and that the methods and motives have varied widely with cultural progress.

#### CLASSIFICATION

The operation of trephining, as performed by different peoples in the several culture stages, may be regarded from different points of view, and so classed in different ways:

Classed with respect to period, the operation may be considered as (1) *prehistoric* and (2) *modern*.

Classed with respect to the methods employed, trephining may be considered as (1) *primitive* and (2) *specialized*. Primitive trephining may be defined as that performed by means of implements or tools either undifferentiated or specialized for other functions; specialized trephining may be defined as that performed by means of instruments designed and made for the purpose. Under these definitions, primitive trephining comprises all the known prehistoric operations, the operations performed by the South Sea islanders, and the rude, rural trephining of domestic animals; while specialized trephining embraces not only the highly developed operations of modern surgery, but also such crude operations as those of the Kabyle, when performed by trained shamans with special apparatus. These primary classes are so broad as to be susceptible of subdivision. Accordingly, primitive trephining may be considered as (a) *archaic*, or that performed anciently or without knowledge or use of metal, including the prehistoric operations and

those of the South Sea islanders, and (*b*) *neoteric*, or that performed modernly, or by means of metal, including the skillless operations on domestic animals. Commonly, or always, neoteric trephining is accultural, and represents the engrafting of a higher technology on the stock of a lower sophiology. Specialized trephining may in like manner be subdivided into two classes—(*a*) *rude*, or that performed in a simple and barbarous manner by untrained or shamanistic operators without knowledge of physiology, as among the Kabyle; and (*b*) *refined*, or that performed skillfully and intelligently, as by civilized surgeons.

Classed with respect to motive or purpose, trephining may be considered as (1) *thaumaturgic* and (2) *therapeutic*. Thaumaturgic trephining is presumed to act in an occult or mystical way, either for the good of the sufferer or for the benefit of the operator or others; it may be styled (*a*) *vicarious*, when designed to benefit the operator or others, and (*b*) *sortilegic*, when practiced in the interest of the sufferer. Vicarious trephining as thus defined is commonly (so far as known through observation, always) post-mortem, while sortilegic trephining must be essentially ante-mortem. Under these definitions the prehistoric trephining recorded by Broca, Fletcher, and others must have been vicarious, at least so far as post-mortem; while the operations exemplified among the South Sea islanders, and perhaps also among the Kabyle, are sortilegic, and thus occupy a well-marked early stage in the development of medical practice. Therapeutic trephining may be defined as that employed intentionally and intelligently, and without regard to the supernatural, to relieve a disorder; and it may be either (*a*) *empiric*, when it is not, or (*b*) *scientific*, when it is, guided by knowledge of physiology or etiology, one or both.

Trephining may be classed also by the culture-grade of the people practicing it, as (1) *savage*, (2) *barbaric*, and (3) *civilized*; or, more conveniently, as (1) *uncivilized* and (2) *civilized*. This classification crosses, and in a measure corrects, the grouping by period, since it emphasizes the persistence in some countries of characteristics which in other countries existed only during the prehistoric past.

These classes are defined from the standpoint of anthropology rather than from that of surgery or medicine in general; yet their recognition seems essential to comprehension of the origin and development of one of the most remarkable among the triumphs of modern surgery. Their significance is such as to warrant juxtaposition and careful comparison:

Period	Method		Motive		Culture-grade
Modern	Specialized ..	{ Refined Rude	Therapeutic...	{ Scientific Empiric	Civilized
Prehistoric	Primitive ...	{ Neoteric Archaic	Thaumaturgic.	{ Sortilegic Vicarious	Uncivilized

On comparing the method classes with the periods and culture-grades, it is found that archaic trephining was chiefly prehistoric and exclusively eodemotic, but that neoteric trephining persists, at least vestigially, among backward representatives of civilized peoples; yet that



in general primitive method coincides with uncivilized culture. In like manner it is found that rude trephining, as displayed typically among the Kabyle, is distinctively above that of the prehistoric period and demonstrates a differentiation of labor and a social organization transcending that of simple kinship, so that it falls logically into the civilized stage, while refined trephining belongs to advanced culture.

When the motive classes are compared with the others, it is found that vicarious trephining is wholly prehistoric so far as present knowledge extends, and that both the vicarious and sortilegic operations are essentially uncivilized, though the sortilegic practice is found in modern times among peoples of the lower culture status. So, too, the vicarious operation was performed by the archaic method, while the sortilegic operation is essentially neoteric, though the thaumaturgic motive outlived the primitive method so far as partially to control the rude operations of the Kabyle class. Similarly the empiric operation is characteristically rude, and in general pertains to the modern period and marks the transition from uncivilized to higher culture, while scientific trephining is modern in period, refined in method, and civilized or enlightened in culture-grade.

These coincidences are too many and too close to be fortuitous, and the classes can be regarded only as indices to the progressive development, if not to the origin, of trephining and of so much of surgery as is involved therewith.

#### ORIGIN AND DEVELOPMENT

Trephining is one of the boldest operations of modern surgery, rivaling plastic surgery and cœliotomy as a revelation of the ambition and ability of the trained practitioner to explore, modify, re-create, and in every way shape to his liking even the most delicate parts of living organisms. Yet, remarkable as is the modern achievement of specialized trephining, it pales before the marvel of primitive trephining, which is proved by indisputable, though all but incredible, evidence to have been performed habitually and successfully by barbaric and even savage peoples during remote ages. The archeologic and ethnologic records prove not merely the occurrence of the operations in prehistoric times and among various tribes, but indicate that among certain primitive peoples the operation was better known than in modern civilization, more common even than in modern hospitals. Among the Kabyle, students are impressed by the number of individuals who have undergone the operation; among the South Sea islanders, the observers report that nearly every male adult has been trephined once or oftener; and among the prehistoric ossuaries of southern Europe the proportion of trephined crania is strikingly large. Perhaps the best evidence as to the frequency of the operation among the primitive people of the world is that afforded by the Muñiz collection, with its ratio of 2 percent of trephined individuals and 2.5 percent of operations to entire

crania—a ratio probably higher than that of any modern military hospital, and scores or hundreds of times higher than that of the average cemetery of civilization. Most of the bolder operations of recent surgery are of modern invention, many of them reflecting (in successful practice at least) the career of a leader still living, Sir Joseph Lister; but trephining boasts an origin so remote, a lineage so long, an ancestry so eminent, as to claim a special place among the medical arts. It would be difficult to find a more striking illustration of the persistence of a remarkable custom throughout the stages of cultural development than that exemplified in trephining, and the example is of the first importance in illustrating the development of the healing art with which it is connected.

Reviewing the relations epitomized in the table, it may be noted particularly that the practice of trephining has not only outlived the complete transformation in technology which accompanied the passage from stone to metal, but has survived all of the most profound intellectual revolutions in the history of mankind. As a corollary of this striking proposition (which is fully established by the facts summarized in the table), it may be noted particularly, also, that trephining was not originally a curative treatment; indeed, the early practitioners had no conception of real curative or restorative treatment, no glimmering of physiologic or etiologic knowledge, no idea of relation between health and disease, no definite notions concerning the conditions of life and the causes of death. As a scholium to this corollary, it may be particularly noted, finally, that the practice of trephining has survived transformation in motive and has persisted only through the gathering of new motives as knowledge has progressively grown up.

Thus the history of trephining is complex, and it is not easy, from the standpoint of modern knowledge, to perceive how or why the practice was pursued in any generation or in any succession of generations before the development of scientific motives and refined methods. True, it may be stated as a general law—the verity of which is not generally recognized, though it may confidently be affirmed—that, save sometimes in the modern stage of invention, men learn how and why they act only by acting, so that the action precedes its own explanation; yet even this law does not fully elucidate the origin of a peculiar, not to say monstrous, course of action, nor does it clearly indicate how such an operation, visibly accompanied by great suffering and often attended by loss of life, could have originated intelligently or could have persisted even if it originated accidentally. Manifestly the chief difficulty in the way of explaining the origin of trephining grows out of the fact that the operation was discovered and was long practiced before the motives actuating enlightened men were developed; and it follows that search for the origin of the operation can be hopefully conducted only in the light of knowledge of the motives of primitive men. Fortunately the way in which barbaric and savage people think is coming to be understood; and the light thus given illumines fairly, though at some points faintly, the wonderful course of development of the art of trephination.



Primitive men are mystics. In the earliest stage in the development of belief, all objects, but especially the rare and unfamiliar, are supposed to be imbued with mysterious attributes and powers which are exercised capriciously for the good or the evil of the egoistic and egotistic thinker—for magnification of the ego is the leading characteristic of primitive thought. Thus, in this stage, primitive man considers himself surrounded by mysterious potencies, beneficent and maleficent, whose favor is sought by propitiation, which commonly takes the form of fetich-worship, amulet-wearing, and oblation. As this stage in the development of belief advances, the mysterious potencies are segregated; some are regarded as more beneficent or maleficent than others; and the supposed actions of the imaginary powers gradually come to be held as less capricious, more uniform or regular, than at the outset. In the second stage of the development of belief, the mysterious potencies are still further segregated and ascribed mainly to animate or self-moving things, and in time animals, particularly the strong, the swift, and the venomous, are deified. In this stage the veneration of animal totems, the taboo, and other curious customs develop, while amulet-wearing and oblation persist. In this stage, too, inimical men and women, both alien and intern, are assumed to possess mystical powers, and witchcraft and a peculiar fear of and veneration for members and fragments of the human body arise; thus incantation and sorcery through nail-parings, hair-combings, and other parts of the person (the synecdochic magic of Mason), and the wearing of scalps or fingers or teeth of slain enemies, first as charms and later as trophies, grow up as features in formal or ceremonial propitiation of mysterious powers. As this stage advances, the deific animals are presumed to possess supernatural forms as well as powers, and thus the age of dragons and chimeras and goblins and molochs is introduced. In the third stage in the development of belief, the mysterious potencies are so far classified and arranged as to correspond with the powers of nature—the action of sun and moon and stars, of thunder and lightning, of winds, of storm-waves and torrents, of the cold of the north and the winter, etc—and these are personified first as beast-gods and later as anthropomorphic deities. In this stage, incantation and sorcery gradually become incongruous with the developing belief, and either disappear or (under a curious law, exemplified in biology as well as demology, which may be called the *Law of monstrosities*)<sup>1</sup> pass into divination or sortilege, which leads into necromancy or jugglery, such as culminates among the fakirs of India, or grow into

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<sup>1</sup>As is well known, when deep-sea fishes are traced downward into the abysmal depths where the light is faint, the eyes of some species disappear, while those of others are abnormally developed; it is also well known that when a flora is traced into the desert, some plants become dwarfed and shrunk with the diminishing moisture, while others develop tumid and pulpy trunks to fit themselves to the changed conditions. In like manner, when a belief outlasts the conditions under which it was developed, it may be either abandoned or modified; in the latter case the modification soon becomes incongruous with the ever-changing conditions, when it is again necessary either to abandon or modify; and thus beliefs tend to develop into persistent extravagancies with respect to both concept and ceremonial. It is needless for the present to trace this tendency in detail or to enumerate the many striking illustrations of the law.



trial by ordeal, as among our own ancestors; yet invocation and sacrifice persist, and amulets retain their hold. By Powell these stages in the development of belief are respectively denominated hecastotheism, zootheism, and physitheism.<sup>1</sup> Some knowledge of these stages in the development of belief is requisite for comprehension of the motives and mental operations of primitive men.

There is a human trait characteristic of all stages of development, and especially prominent in the earlier stages, which bears directly on the discussion of the motives of early men; it results in what may be called the *Law of the development of fable*. The mind is so constituted as to demand explanations; at the same time it is prone to offer and accept the chaff of hypotheses in lieu of the grain of full understanding; and these tendencies are specially prominent in the communion of children and adults. A pertinent illustration of the trait is the development of belief in shades of the departed, which is, in many respects, parallel to the recognition of mysterious potencies or doubles of things in hecastotheism. The hunter dies; the sages of the clan or tribe, warned by experience, forestall dispute concerning future ownership of the favorite weapon by burying it with his body. The children ask why the weapon was buried, and their elders, ignorant of the real reason, say the hunter still has need of it; so the children are strengthened in their notion of mysterious potencies, and think of the hunter as still using his favorite weapon in a mystical hunting ground. But in all stages of development, belief runs a close race against cupidity, and is sometimes distanced; so the sages learn that even a buried weapon may be a source of contention, which they thenceforward forestall by breaking or burning it. Again the children ask why, and the ill-advised elders are put to the further explanation that the broken or burned weapon is none the less serviceable to the dead hunter, since it is thereby changed only as he is changed; so the hypothesis of mysterious shades is strengthened and extended to weapons, and eventually to favorite animals, as well as to the huntsmen and their consorts. In time the easily satisfied children become the sages of their clan or tribe, and lay down simple yet definite laws in accordance with their early notions concerning shades. They are unable to find the shadowy hunting ground, and consequently argue that it must be a long way off, and that the dead hunter must needs be provisioned against the journey; so food and drink are buried or burned with the dead, and the children are regaled with enriched hypotheses; and through the union of natural affection, belief, and ceremonial the lifeless body becomes a doubly mysterious and sacred thing, and, if the stage of development is that of synecdochism, a mysteriously potent thing. This is only one of the ways in which the primitive (and even modern) tendency to explain by half knowledge is developed into motive-shaping belief; the ways are legion.

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<sup>1</sup>The subject of primitive belief is developed somewhat more fully in "The Siouan Indians," Fifteenth Annual Report of the Bureau of Ethnology, for 1892-93, (1897) pp. 153-204.

Understanding primitive motives and mental traits, and the modes of thought which they reflect, it is not difficult to discover the origin, or at least a quite early stage in the development, of post-mortem trephining; and it is possible to buttress on this basis a partly hypothetic bridge spanning the chasm between post-mortem vicarious operations and ante-mortem trephining, both thaumaturgic and therapeutic. When, in the stage of amulet wearing and synecdochism, the warring tribesman slew an enemy, he sometimes mutilated the remains and even ate of the heart, not only in savage triumph, but mainly in order that he might gain the courage and strength of his quondam opponent; and partly as a trophy, but chiefly as a mystical talisman and constant invocation to the powers, he appended the scalp to his spear or belt, or strung the teeth in a necklace, or converted the erstwhile powerful hand into a gorget. This stage and custom are well known among the primitive peoples of the earth. Reaching a little way into the unknown from this buttress of the known, it is easy to see that, save perhaps in the driest climates, the indecomposable teeth would be found more satisfactory talismans than the decomposable scalp or hand, and that, through natural association, the durable skull lying just beneath the evanescent scalp of the mutilated body might easily come to be drawn upon for the amulet trophy. This inference lies close to established fact, since it is well known that certain primitive tribes preserve the entire or mutilated heads of enemies slain in battle. It is but another easy step to the stage in which one or more pieces of the skull (for in synecdochism the piece carries the virtue of the whole) of the slain enemy were used as amulets, either as supplementary to or as substitutes for the teeth. Here again the structure of explanation rests on the firm ground of established fact, as revealed through study of the prehistoric; for it is well known that post-mortem trephining was extensively practiced in certain cases during prehistoric times, and that the rondelles obtained thereby were worn and treasured after the manner of amulets. Thus, in this stage, trephining must have been performed with a definite motive, under the zootheistic belief that the slain warrior vicariously strengthened his slayer. It is probable—nay, certain, as archeologic record indicates—that the grisly custom strengthened through exercise and extended to the taking and prizing of amulets from other skulls than those of enemies slain in battle, so that the custom matured in a cult of morbid and revolting character, in which the growing sacredness of the human body under synecdochic mysticism played an important part.

Here a span in the explanation-structure fails, yet the chasm is not too broad and deep for easy crossing on the scaffolding afforded by study of primitive ideation: The keynote to zootheism is the animate power or self-motility of animals, whereby they are exalted above all self-moveless things; and thus to the zootheist, dominated by synecdochism, the talisman taken from the wounded enemy, while still living, was immeasurably more potent than that taken from the dead enemy; and



so it must have been that the well-known ante-mortem mutilation, which on the one hand grew into the scalping of wounded warriors and the appalling torture found among the American Indians as well as among other savages, must have grown on the other hand (when antecedent conditions were favorable) into ante-mortem trephining of wounded and later of woundless captives. When this stage was reached, experience—which taught primitive men as modern men are taught, though much more slowly—must have shown that sometimes the sufferers survived, and were perhaps even improved. Now, if the practice were continued among a given people into that part of the stage of physitheism in which the cult of kismet prevails (as among so many people in the upper strata of uncivilized culture, including the Kabyle, if not the South Sea islanders), the custom of trephining wounded captives would almost necessarily grow up, with the idea that a mystical significance attached to the operation as a sort of ordeal; the idea might be that, if fate so willed, the captive would thereby become the more perfectly affiliated with the captors, while if Allah decreed death under the knife—so mote it be. There is but one short step more to the solid ground of known fact, i. e., the gradual extension of the fatalistic or sortilegic operation from captives to others; and this transition is in accord with known methods of thought among primitive folk belonging to that stage of physitheism or incipient psychotheism in which the ordeal was developed; for it was quickly perceived among many peoples that if the ordeal was beneficent to one class it could not be devoid of good when extended to other classes. Here again the structure of explanation rests on the firm ground of observation; for the typical trephining of the South Sea islanders, and in large measure the typical Kabyle operation, represent the general sortilegic stage in the development of trephining.

The span of the explanation-structure extending from sortilege to empiricism is long but well supported; for while the transition from purely fatalistic treatment of the sick to empiric treatment of disease was slow among each people, its course has been well observed. Gradually the mysticism, the belief in occult power, waned; gradually the recognition that given treatment (howsoever random) was followed by fairly uniform results waxed. Thus the doctrine of signatures grew into simple therapeutics; thus the belief in blind fate grew into belief in the kingly touch; and thus dimly realized experience of the uniformity of cause and effect made medics out of hermits and beldams and chemists out of alchemists, and in time made nurses and neighborhood practitioners out of sedate and observant men and women. With the tedious revolution in medicine went a slow transformation in surgery, and the shamans and their descendant doctors gradually forgot the ordeal motive, and trephined men and animals in desperate cases because their teachers had done so—and were they not wise men?

The span from empiric treatment of disease to scientific medicine and surgery is not long, and is covered in the history of every civilized

country, and indeed by the range of current thought in America and Europe. Practitioners, like other men, first learn how and then learn why to act through action; the zealous physician scans memory and record of cases in the effort to find a treatment which gives promise of saving his patient; he can not forget trephining, for the records are full of it, his clientele remind him of it, and his rural neighbor perchance practices it on his beast. He can and does weigh the risk as shown by the results of empiric practice; he can and does consider the physiologic conditions and etiologic bearings of the operation; and in the end the operation is performed or not, as the best judgment of practitioner or consultation may decide. Yet in every case the decision is based largely on the record, and the treatment, if adopted at all, is adopted largely if not mainly by reason of empiric experience rather than by reason of etiologic considerations; indeed, the layman may well question whether the desperate operation of trephining (in contradistinction from simple elevation or extraction of bony fragments in case of depressed fracture) would have been introduced before plastic and intestinal surgery had it not come down from the prehistoric past, a legacy from the darkest ages.

In this way the genesis and development of one of the most remarkable features of medical practice may be traced with a fair if not high degree of certainty. The explanation seems safe, because it rests on well-established fact at many points; it seems just, because it is in close accord with all that is known of the evolution of methods and motives among men. The course of development thus traced is not only of interest in itself and in its bearings on the trephining of Peru, but is of much significance in its relation to the development of other branches of surgery and medicine.

It remains to interpret the Muñiz collection in the light of the history of trephining as thus outlined, and then to consider the facts revealed in this collection as bearing on the history.

#### THE CRANIA IN DETAIL

##### COMMON FEATURES

Collectively the crania are notably small and variable in form, as indicated by the illustrations, which depict different aspects on a scale of two-thirds linear. With one possible exception, all are adult and some fully mature, as indicated by the condition of the sutures. Considered collectively the cranial bones are remarkably thick and strong, only one or two of the specimens approaching the Caucasian normal in respect to thinness. The tendon and muscle attachments are notably prominent, rugose, and striated, indicating vigorous physical development. In several cases the supernumerary interparietals known to archeologists as "Inca bones" are found. In one fully adult specimen the metopic suture is distinctly preserved; and in general the sutures, especially the lambdoid and the posterior portion of the sagittal, are remarkably crenulate.



## CRANIUM 1

*(Plates I, II)*

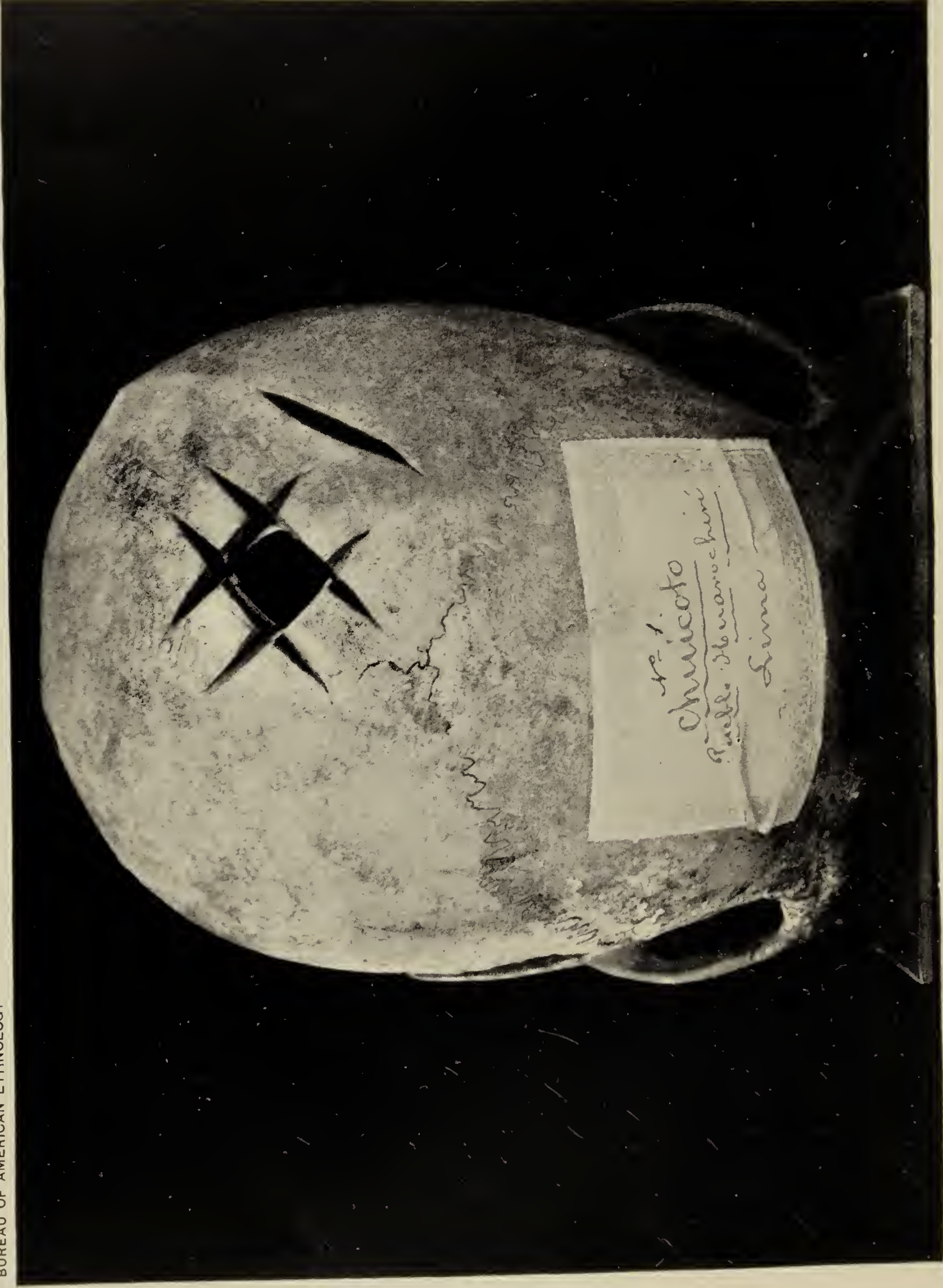
Excepting a spot on the right side, which is somewhat weathered and eroded through exposure, this skull is firm, strong, and exceedingly well preserved. It was taken from a semimummified body, and shreds of tissue remain attached. It displays a single operation, so far completed as to reveal the methods pursued by the primitive practitioner with remarkable clearness, together with an incomplete supplementary incision. The thickness of bone, measured on the incisions, is 6 to 7 mm. The condition of sutures and teeth indicates mature but not advanced age.

The operation was located near the crown, i. e., in the upper and forward part of the left parietal, involving the sagittal suture and approaching the frontal. The aperture is an approximate parallelogram, averaging 17 by 22 mm., measured on the outer surface, and about  $2\frac{1}{2}$  mm. less, in either dimension, measured on the inner surface. As clearly shown by the projecting extremities, the rectangular button was dis severed by means of two pairs of approximately parallel incisions, crossing approximately at right angles. All of the incisions were more extended than the aperture, ranging from 42 to 50 mm. in length. The incisions are V-shape in cross-section; none end abruptly, but simply narrow and shallow to the points of termination. The two more nearly longitudinal incisions are sharply defined quite to the termini, though there is a minor cut nearly parallel to the medial cut (shown in plate I), indicating a change in position and direction of the incision early in the operation. The lateral extremities of the transverse incisions are somewhat indefinite, showing a number of scratches and cuts produced by slips or clumsy manipulation of the instrument. (These marks are imperfectly reproduced in the plates.) All four of the principal incisions penetrated both tables of the skull for a part of their length, both the transverse cuts (especially the posterior one) passing beyond the medial longitudinal incision in such manner as to show that the intracranial tissues must have been injured by the operation; while at the latero-posterior angle the rudely executed incisions did not extend quite through the inner table, and a projecting edge of bone remains, suggesting that the button was removed by the use of an elevator inserted at the medio-anterior corner.

There is no indication of effort to smooth the sharp edges left by the cutting, nor is there any indication of subsequent growth. Moreover, there is some discoloration of the bone about the incision, indicating incipient decomposition in advance of mummification. Accordingly it seems probable that the individual did not survive the operation—indeed the posterior transverse incision must have penetrated the meninges and invaded the cerebral tissue for a length of 12 mm. and a depth and width of 2 or 3 mm., and must have produced or hastened death.







SUPERIOR ASPECT OF CRANIUM 1, FROM HUAROCHIRI



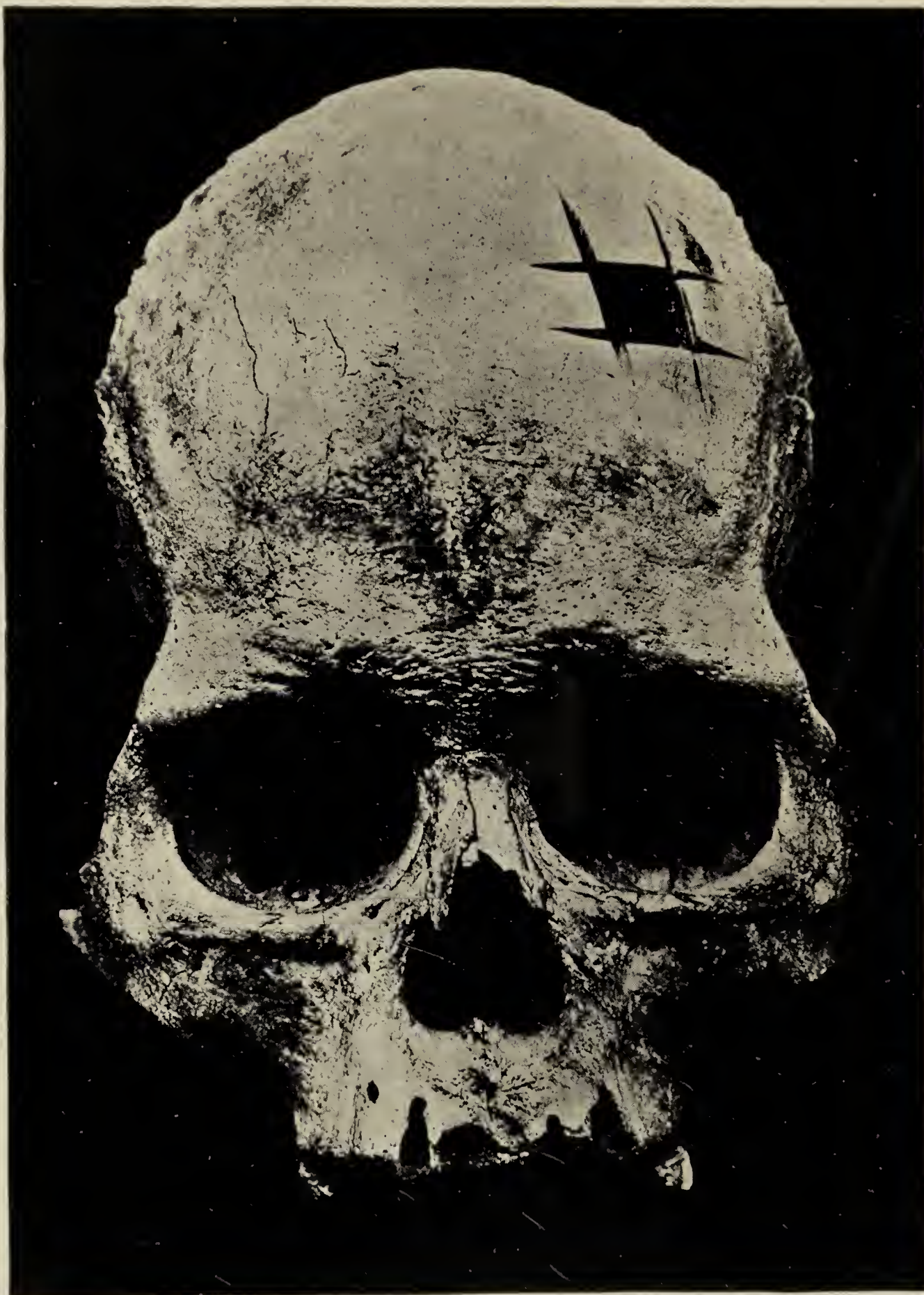




LEFT LATERAL ASPECT OF CRANIUM 1

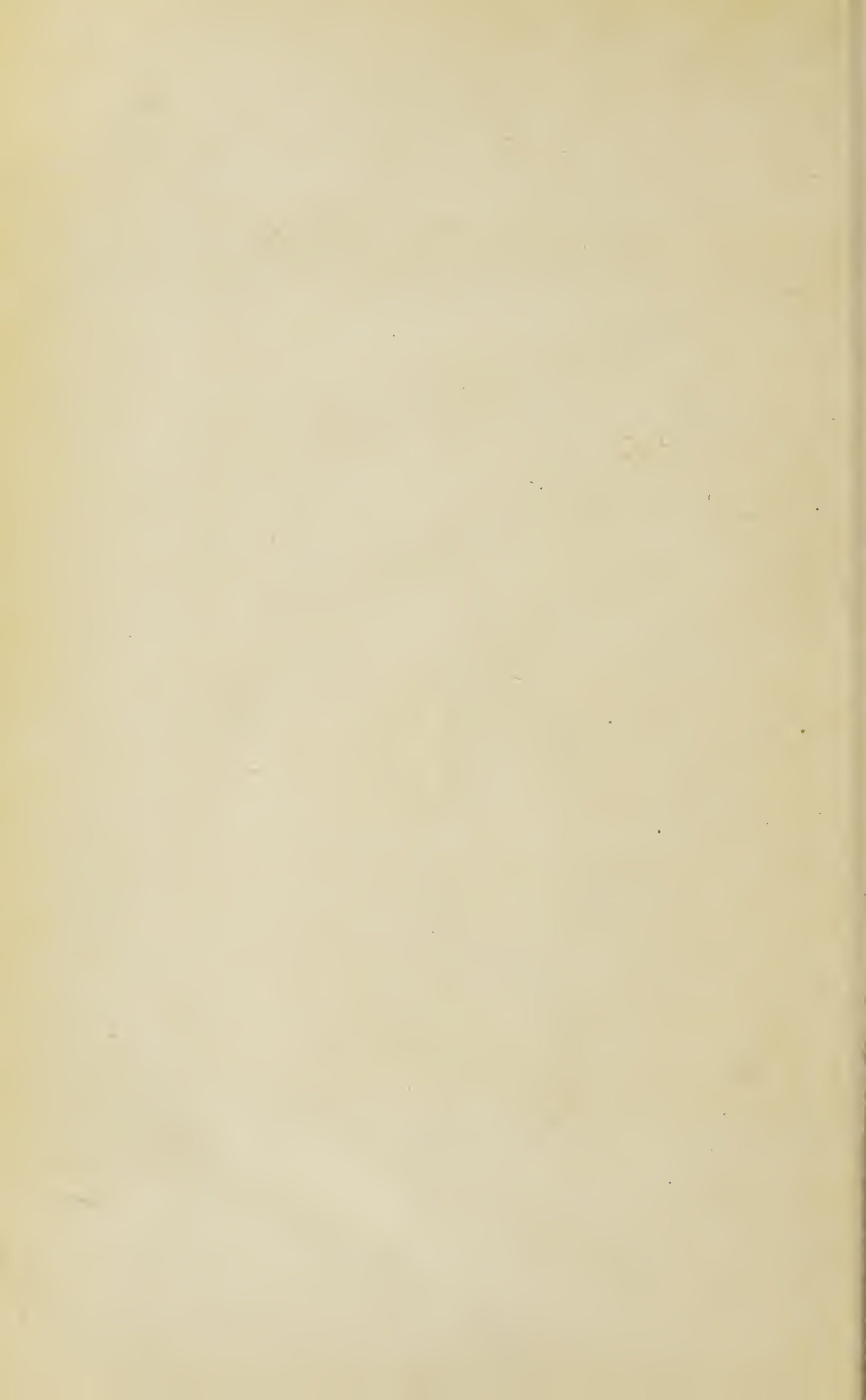






ANTERIOR ASPECT OF SQUIER'S "INCA SKULL"







The supplementary incision is about 20 mm. below the aperture, near the center of the anterior part of the left parietal, and nearly parallel with the more nearly longitudinal incisions of the principal operation. It is precisely like the main incisions, V-shape in section, 42 mm. long, 5 mm. wide, and 6 mm. deep toward the center, where it does not quite penetrate the inner table of the skull, narrowing and shallowing gradually toward the extremities. Just below its center there is a transverse scratch (hardly visible in the plate), apparently marking a transverse incision barely started when this part of the operation was abandoned. There is a similar faint scratch back of the main aperture, between and behind the main longitudinal incisions, and approximately parallel with them, which appears in the reproduction.

The preservation of the specimen is so perfect as to reveal even the faintest scratches produced in connection with the operation, and thus to indicate the character of the instrument and the mode of its use. The scratches, both random and at the ends of some of the incisions, show that the instrument had a single moderately sharp point, thickening rapidly to 3 or 4 mm. within 6 or 7 mm. from the tip; that not only the point but the sides bit into and ground away the bone as it was manipulated; and that the manipulation could only have been a reciprocal motion back and forth from end to end of the incision, accompanied by considerable pressure. It is noteworthy that no known metal instrument or implement would produce the general and special features of the incisions in this cranium, while all the features of incisions and scratches are precisely such as would be produced by a sharpened stone in the form of a spearhead, arrowpoint, or knife.

In addition to the operation and supplementary incision, the cranium displays a few significant marks. The most conspicuous of these is almost exactly in the center of the frontal bone, some 40 mm. above the orbital ridges; it is a narrow, longitudinal contusion, 20 mm. in length, along which the bone is crushed irregularly, in such manner as to indicate impact of a moderately sharp but rough-edged instrument, the force of impact being such as to produce a curvilinear crack in the outer table, nearly parallel with the contusion, and joining it at the ends. The appearance of this lesion indicates that it was produced during life, though there are no marks of reparative process. Near the left margin of the frontal bone, some 50 mm. above the left orbit, there are two deep grooves 2 or 3 mm. wide and 15 mm. and 20 mm. long, respectively, partly obliterated by reparative process, evidently marking old wounds. (The three marks are concealed beneath the label.)

For comparison with the Muñiz specimens, a photomechanical reproduction of the "Inca skull," brought from a cemetery in the valley of Yucay, Peru, by E. G. Squier, is introduced in plate III, from a photograph taken in the United States Army Medical Museum.<sup>1</sup> The oper-

<sup>1</sup>A wood engraving from this photograph forms plate VII of Dr Fletcher's memoir "On Prehistoric Trephining and Cranial Amulets," cited above. A wood engraving of the same skull appears on p. 457 of Squier's "Peru—Incidents of Travel and Exploration in the Land of the Incas."

ation displayed by this specimen is precisely similar to that exemplified in cranium 1 of the Muñiz collection; the aperture is 0.58 inch by 0.70 inch. The Squier specimen shows (obscurely in the accompanying plate) the extent of the removal of the periosteum. It was examined by Broca, who thought this was done eight or ten days before death, and by Nelaton, who suggested that the subject might have survived fifteen days.<sup>1</sup>

## CRANIUM 2

(*Plates IV, V*)

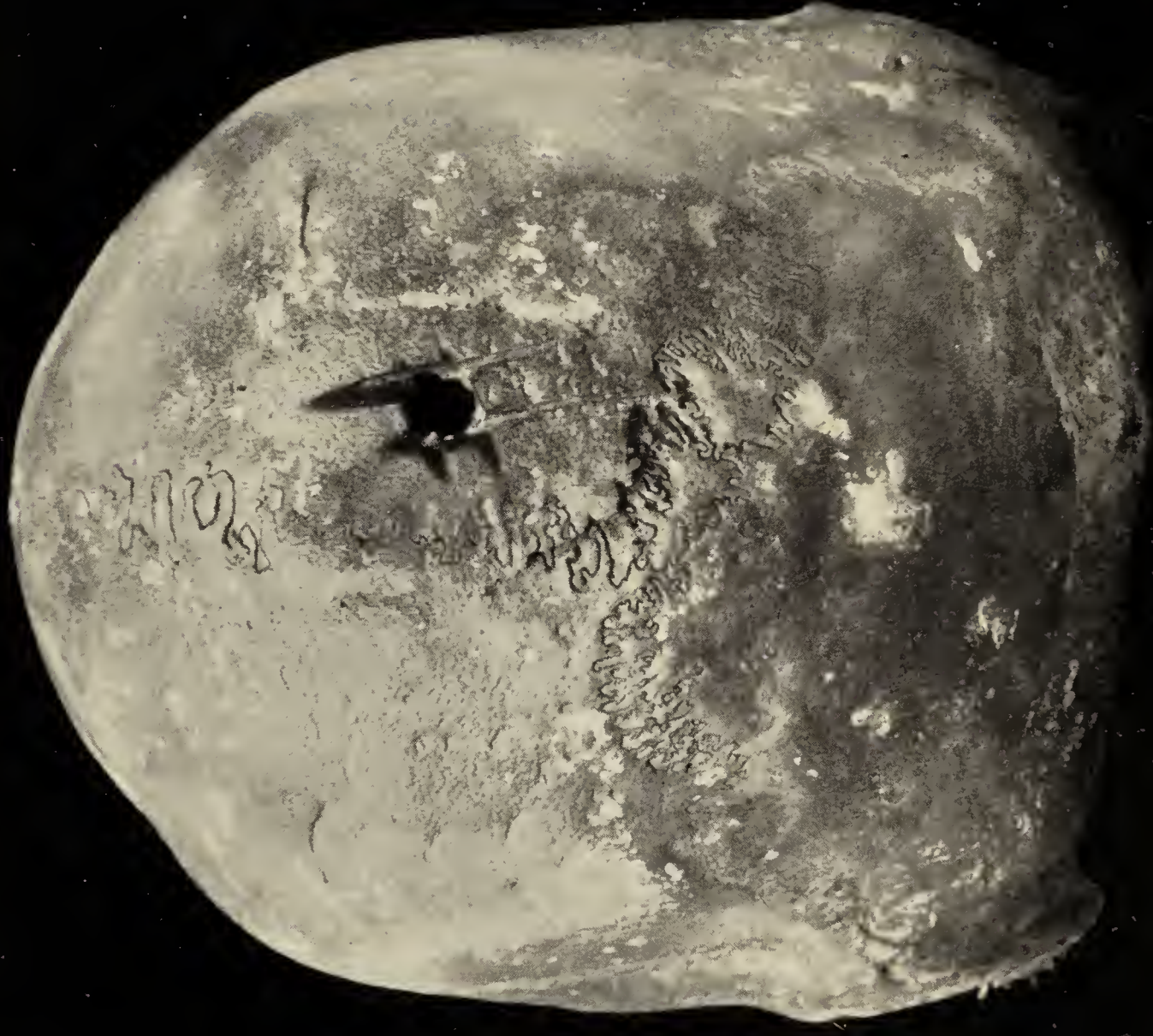
This specimen, like the last, is finely preserved and strong, and bits of stout tendon remain attached. The frontal and temporo-parietal sutures are nearly ankylosed, though the lambdoid is distinct (showing several supernumeraries), indicating, on the whole, full maturity. The specimen shows a single operation, about which the bone is 5 or 6 mm. in thickness.

The operation was located near the posterior angle of the right parietal, approaching both the sagittal and lambdoid sutures. As in the first cranium, an approximately rectangular button was dissevered by means of two pairs of parallel incisions. The aperture is remarkably small, averaging 9 by 10 mm. measured on the outer surface and considerably less measured on the inner surface. The incisions are V-shape in section and project beyond the aperture, though much less than in the first specimen; the longitudinal incisions are the longer, measuring about 26 and 35 mm., respectively, and show random scratches toward the posterior extremities; the transverse incisions are only 16 or 17 mm. in length, barely crossing the transverse incision on one side and projecting but 4 or 5 mm. on the other. The incisions, like those in the first specimen, show every indication of having been made by a single-point, tapering instrument, so constructed as to abrade on the sides as well as at the tip; they are much too wide and too strongly curved in plan and section to permit the supposition that the instrument was metal, and are just such as would be produced by a stone tool. The operation would appear to have been more skilfully performed than the last, since the incisions are much shorter in proportion to their depth, and so placed as to involve a minimum expenditure of labor and suffering, in view of the rude character of the instruments employed. Two of the incisions only appear to have penetrated the bone, and the rough edges of the inner table remaining indicate that an elevator was applied to break out the button so soon as the bone was sufficiently attenuated, while the superior and lateral kerfs evidently penetrated not only the inner table but the meninges. There is no sign of smoothing of the sharp edges of the bone after the operation, nor is there any trace of reparative growth to indicate survival; moreover, there is some local discoloration of the skull suggesting local decomposition before mummification. In addition, the bone, for some distance about

<sup>1</sup> Peru, op. cit., 577.



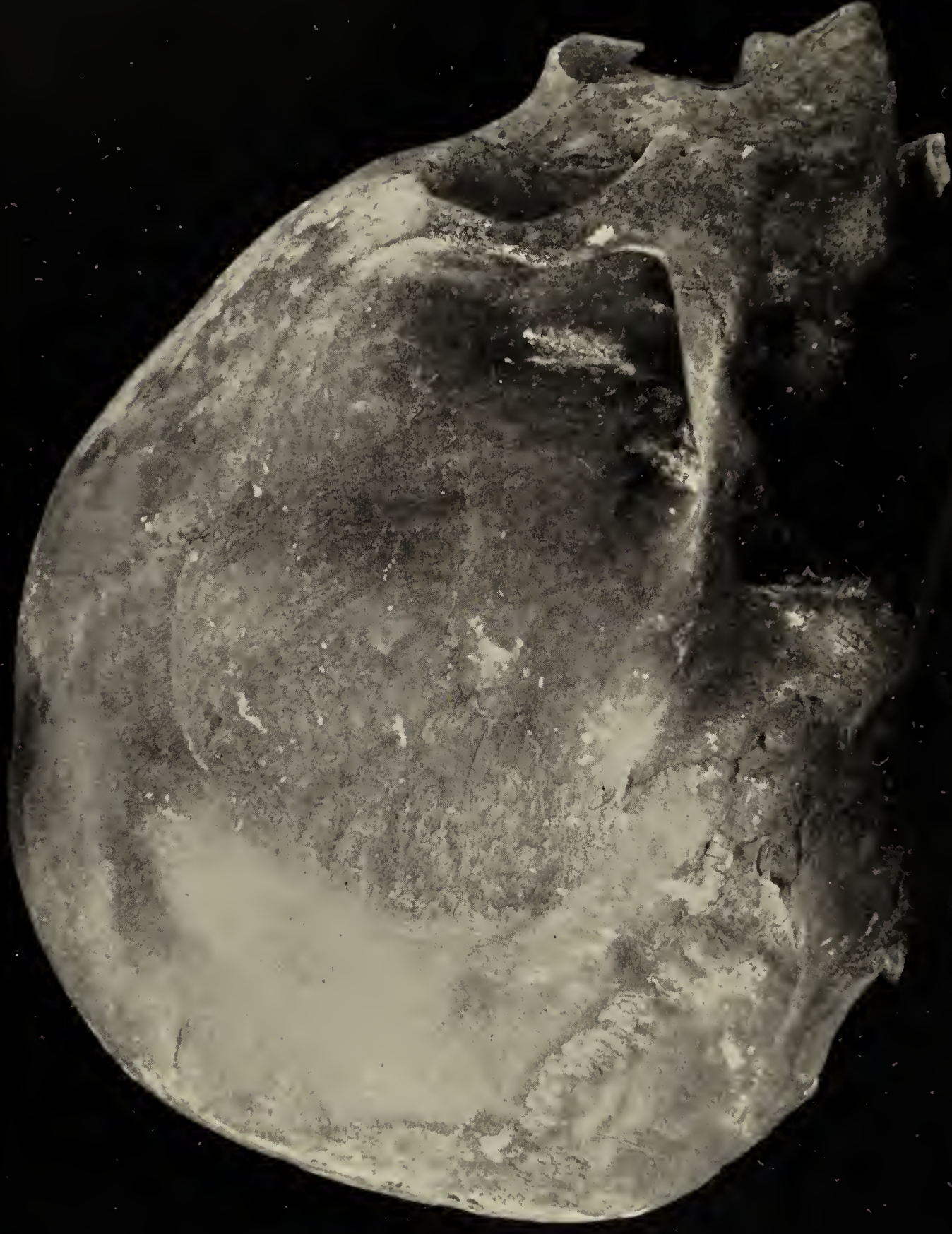




POSTERIOR ASPECT OF CRANIUM 2, FROM HUAROCHIRI



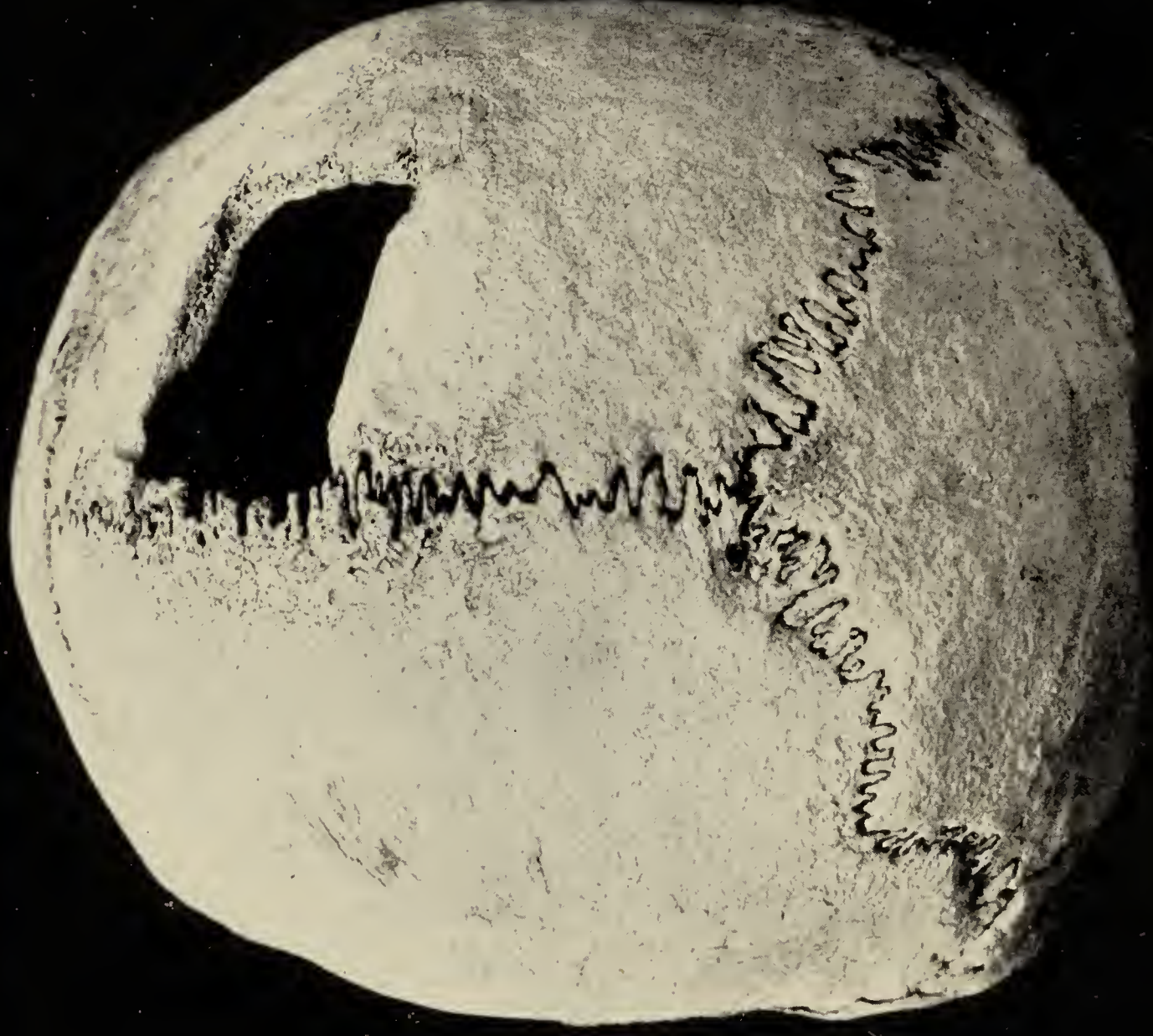




RIGHT LATERAL ASPECT OF CRANIUM 2







SUPERIOR ASPECT OF CRANIUM 3, FROM CAÑETE







RIGHT LATERAL ASPECT OF CRANIUM 3







the point of operation, displays a somewhat corroded and spongy appearance, indicating an abnormal condition during life, probably periostitis. Thus there is a suggestion that the operation was antemortem, and connected with a diseased condition; and there are indications that the sufferer did not survive the treatment.

This cranium displays also a few marks apparently due to old contusions or wounds, nearly obliterated by reparative process; the most conspicuous are clearly shown in the reproductions on the right and left of the operation in a somewhat higher horizontal plane (these may be pathologic); and there is a long vertical groove over the left temple.

### CRANIUM 3

(*Plates VI, VII*)

[ This specimen is much weathered and eroded, no trace of tissue remains, and the weaker bones and processes are fragmentary or absent. The condition of the sutures indicates maturity. A single operation is displayed, revealing a thickness of bone varying from 5 to 7 mm.

The operation was performed on the right side of the crown, i. e., near the middle of the upper margin of the left parietal, apparently just involving the sagittal suture. While the condition of the skull is not such as to indicate the details of the operation, it evidently consisted in making two pairs of approximately parallel orthogonal incisions, as in the previous cases. The aperture is large, averaging 35 by 40 or 42 mm., measured on the outer surface, and 2 or 3 mm. less in either dimension measured on the interior; but the transverse (and longer) dimensions can not accurately be determined, since the narrow selva of bone between the superior longitudinal incision and the sagittal suture is lost. The incisions projected somewhat beyond their orthogonals, in one case so much as 8 or 9 mm., and the bone is well enough preserved to show that they were V-shape in section, narrowing and shallowing to the termini, as in the preceding specimens.

There is nothing to indicate whether the operation was late antemortem or early post-mortem, no smoothing of sharp edges, no reparative growth, no indications of diseased condition of bone or periosteum, no definite trace or lesion other than that of the operation.

### CRANIUM 4

(*Plates VIII, IX*)

This specimen is bleached and somewhat weathered and broken, though in good condition about the locus of the single operation. The sutures are incipiently ankylosed, indicating maturity, though the posterior molars are immature. The cranium is much lighter and thinner than the average of the collection, being fairly comparable in this respect with the Caucasian normal; as revealed in the aperture, the bone ranges from 2 to 3½ mm. in thickness.

The operation, located in the frontal bone on and to the left of the median line, cornering just above the left orbital ridge, was incomplete. It comprised two approximately orthogonal trios of approximately rectilinear incisions, each similar to those of the preceding specimens, so placed as to describe four contiguous quadrilateral buttons, of which one remains in place. The aperture, if completely opened, would average about 30 by 37 mm. The six incisions are V-shape in section, narrowing and shallowing to the termini, and project 3 to 14 mm. beyond their orthogonals; and there are a few random scratches, giving the usual testimony concerning the character of the instrument employed. The incompleteness of the opening, in conjunction with the relations of the incisions, indicate clearly the procedure of the operator. Evidently the operation was begun with only a vague notion as to the dimensions of the button to be removed, and the operator clumsily located the incisions in indefinite fashion rather than in accordance with a clearly formed plan; and as the two outer incisions approached the supra-orbital ridge they were diverted by that prominence in such manner as to give them, particularly the longitudinal cut, a curvilinear form. The appearance of the kerfs indicates that the lateral longitudinal incision through a part of its length, the anterior transverse incision for a short distance, and both the central incisions, completely penetrated the inner table and invaded the intracranial tissues, but that in general the incisions were not carried entirely through the bone, and sometimes only into the diploe, when the operator had recourse to an elevator. The marks indicate also that the elevator was inserted over the interior angle of the medio-posterior button (or quarter button) in such manner as to lift the inner edges of one or more of the other buttons, and that pressure was exerted until they were broken out, singly or together, and until the corner of the remaining button was chipped or spalled off under the strain. At this stage the operation was abandoned, the sharp edges of broken bone being left untouched: and there is no trace of reparative growth.

There is nothing to indicate certainly whether the operation was late ante-mortem or early post-mortem, further than the abandonment of an incomplete operation suggesting death in the hands of the operator, and the cuts extending through the bone and into the cerebral tissues in such manner as probably to produce fatal results; nor are there traces of antecedent lesion.

There is a depression about the center of the right half of the frontal bone, apparently the record of a blow received long before death.

#### CRANIUM 5

(*Plates X, XI*)

This specimen is one of the largest in the collection; it is in good condition, having been taken from a mummified body in a fair state of preservation. The sutures and teeth indicate approaching maturity. The skull is strong and symmetric, though thinner than the average



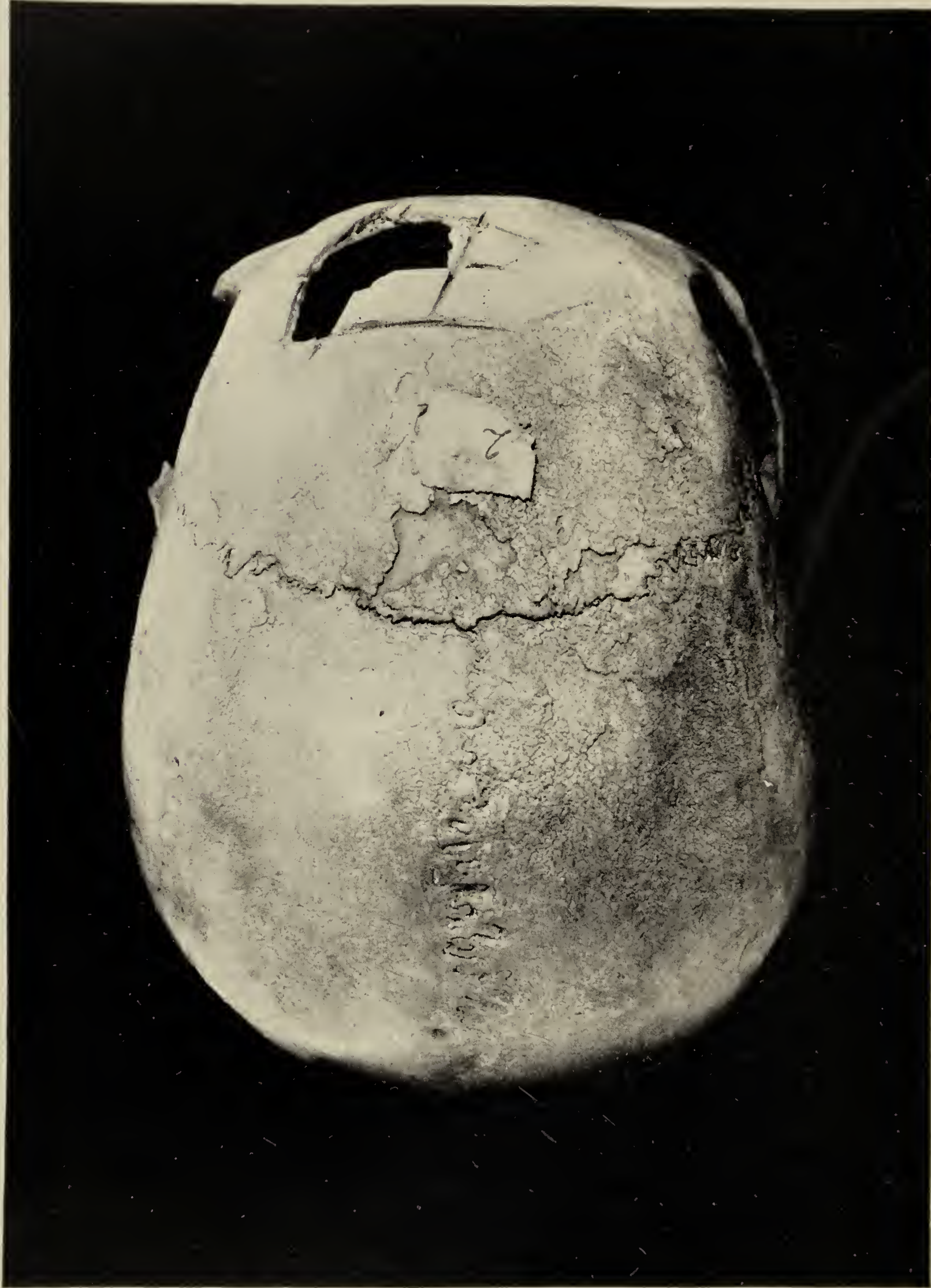




ANTERIOR ASPECT OF CRANIUM 4, FROM HUAROCHIRI







SUPERIOR ASPECT OF CRANIUM 4







ANTERIOR ASPECT OF CRANIUM 5, FROM HUAROCHIRI







SUPERIOR ASPECT OF CRANIUM 5







of the collection, ranging from  $2\frac{1}{2}$  to  $5\frac{1}{2}$  mm. about the single extensive aperture. There are three distinct interparietal bones, one 25 mm. across, the other smaller.

The operation represented by the specimen was performed on the right side of the frontal bone, extending from the median line to the coronal suture, passing about 30 mm. above the orbit. It was performed by means of a number of rectilinear incisions of the usual V-shape section and attenuated termini. While somewhat random in distribution, the outer incisions cross at large angles, describing a somewhat irregular polygon. In addition to those made about the aperture, there are others extending over to the left side of the frontal bone, indicating far-reaching exploratory and tentative cutting on the part of the operator; and a series of shallow scratches extends backward from the lateral extremity of the aperture for 25 mm. on the left parietal. Including the minor scratches, there were at least twenty different incisions, nearly all penetrating the outer table, with at least four or five penetrating the inner table, in some cases so far as evidently to penetrate also the dura mater. It would appear that, after this hacking of the skull, the operator raised the included fragment or fragments, probably in several pieces, by means of elevators, producing an aperture fully 65 mm. long by 33 mm. in maximum, and some 24 mm. in average width. There was no final smoothing of sharp edges; and naturally there is no indication of subsequent reparative process.

In this case, as in the last, there is a lack of conclusive evidence as to whether the operation was late ante-mortem or early post-mortem, though not only the abandonment of the operation and the nature of the wound produced thereby, but a decided local staining of the skull and absence of soft tissues, bringing to mind the interpretation by the Peruvian commission of the fatal wounding recorded in the cranium of Pizarro,<sup>1</sup> suggest that the instrumentation was ante-mortem and fatal in its results. There is no unmistakable trace of lesion other than the slashes of the rude instrument with which the operation was performed, unless it be an irregular scar or sinuous scratch, about 1 mm. broad and half as deep, skirting the right supraorbital ridge to the median line, and thence wandering upward and toward the left to a point 30 mm. above the center of the left orbit, which on the whole seems to be post-mortem.

It may be observed that both these cases show that it could not have been the design of the operator to obtain a button or rondelle, since the incisions were so placed as to divide the extracted piece into fragments.

## CRANIUM 6

### (*Plate XII*)

This fragmentary specimen is a well-preserved right parietal bone of a relatively thin cranium, measuring  $3\frac{1}{2}$  to  $4\frac{1}{2}$  mm. about the single

<sup>1</sup>"The Remains of Don Francisco Pizarro," *American Anthropologist*, vol. vii, 1894, pp. 1-25, especially p. 7.

artificial aperture. The bone is somewhat bleached and cracked, but is in sufficiently good condition to indicate clearly the *modus operandi*.

The locus of the operation is near the posterior angle of the bone, centering about 40 mm. to the right of the sagittal suture, and the same distance above the lambdoid. The aperture is elliptical, measuring about 22 by 43 mm. on the outer surface, somewhat less on the inner. Evidently it was performed chiefly by means of a single curvilinear incision, apparently followed by the use of an elevator; and the scratches leaving the upper incision show that the curvilinear character was given by gradually changing the direction of the reciprocal or sawing motion as the incision was extended from the anterior extremity inward and backward. The marks indicate, too, that the instrument was a somewhat blunt single-point blade, which ground the bony substance with rough sides as well as a jagged tip. The sharp edges of the bone were not reduced after the operation, nor is there any sign of subsequent physiologic process.

In this, as in some other cases, there is no certain means of determining whether the operation was ante-mortem or post-mortem, though it must have dated about the time of death; but in this instance there is fairly decisive evidence that the operation was located by an antecedent lesion. Seven or 8 mm. outside the posterior extremity of the aperture there is a curvilinear crack in the outer table of the skull which, though partially obliterated by exploratory scratches, can easily be traced to its passage into the lower side of the aperture, where it invades the inner table and coincides with the margin of the opening thence nearly to its anterior extremity. While it would seem barely possible that this fracture might have been produced in connection with the operation, the indications are much stronger (amounting almost to conclusive evidence) that it antedated the operation, and was part of a depressed fracture, in which the bone was broken through in undercut fashion on the lower side of the aperture, and bent inward above, where the incision was afterward placed.

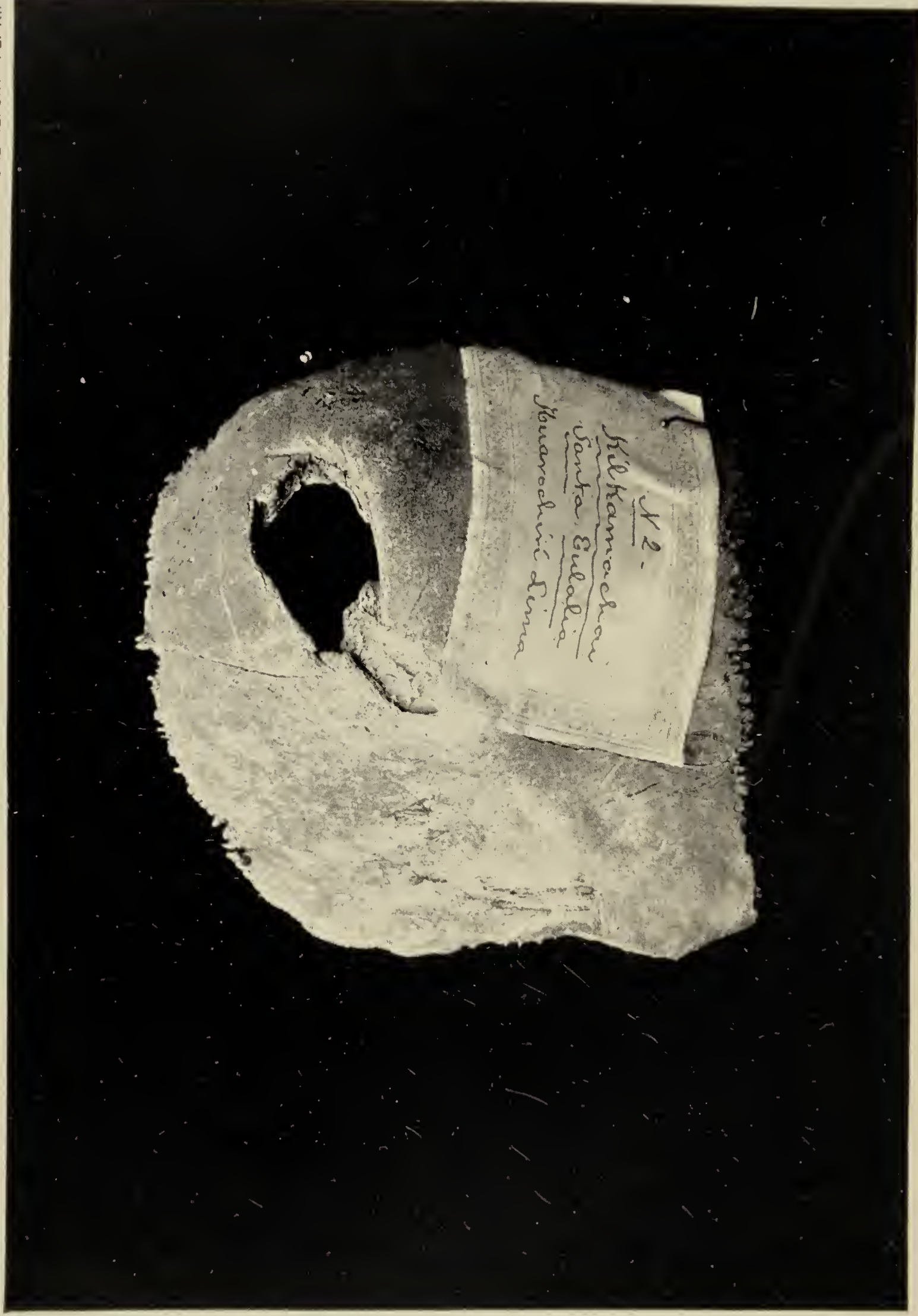
#### CRANIUM 7

(*Plates XIII–XV*)

This specimen is fairly preserved, having been taken from a mummified body, though it is weathered about the lower part of the left side, and somewhat about the occiput; no tissue remains, but portions of the bone are fatty and gelatinous. The skull is quite thick and strong, with an immense occipital protuberance; it measures 6 to 8 mm. in thickness about the loci of the two operations. The temporo-parietal sutures were incipiently ankylosed, as was also the coronal, especially on the right, though the sagittal and lambdoid remain conspicuous, the condition on the whole indicating full maturity. There are two or three irregular interparietals; while the metopic suture is distinctly preserved.

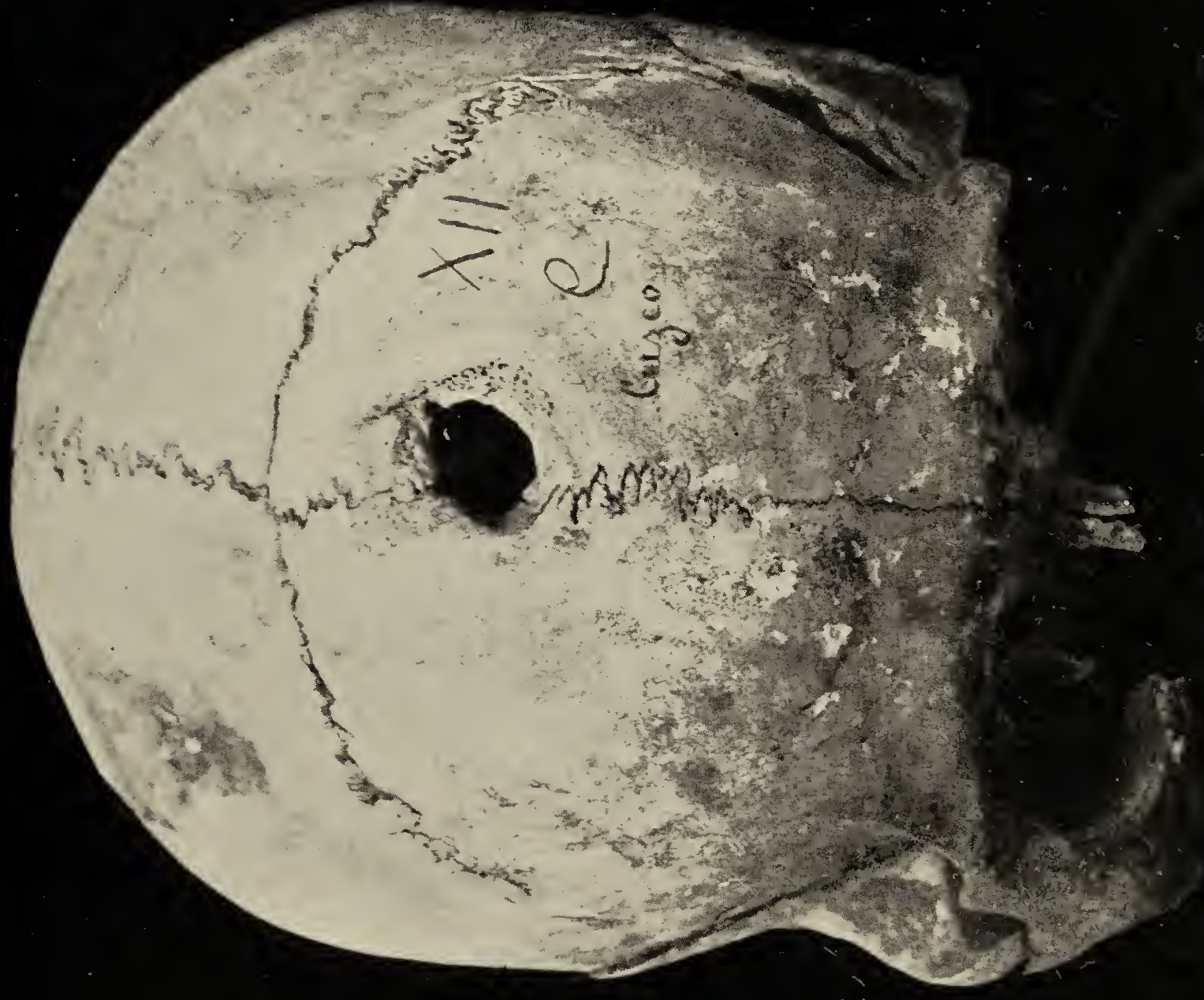






RIGHT LATERO-POSTERO-SUPERIOR ASPECT (INVERTED) OF CRANIUM 6, FROM HUAROCHIRI

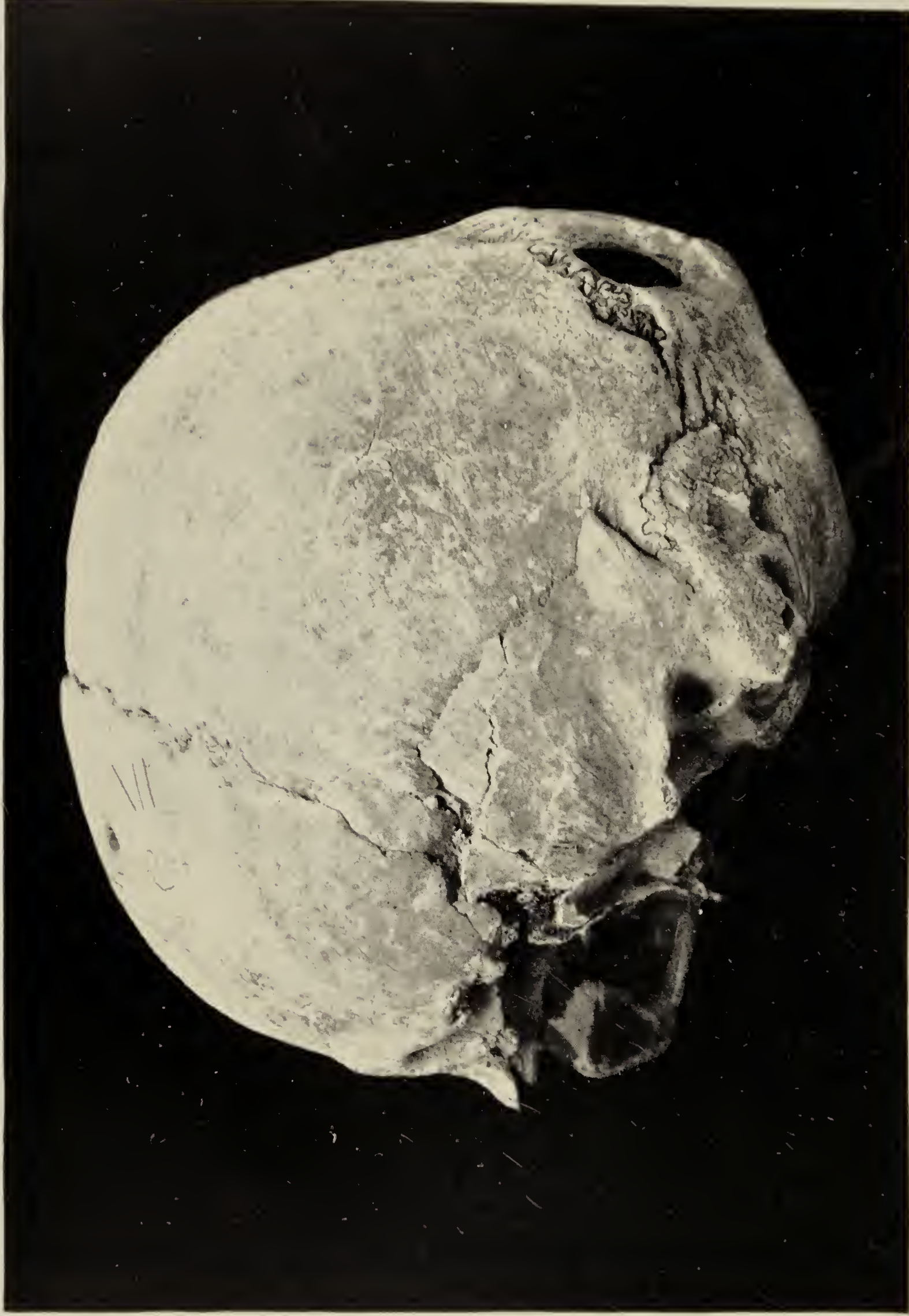




ANTERIOR ASPECT OF CRANIUM 7, FROM CUZCO (DOUBLE-TREPHINED)



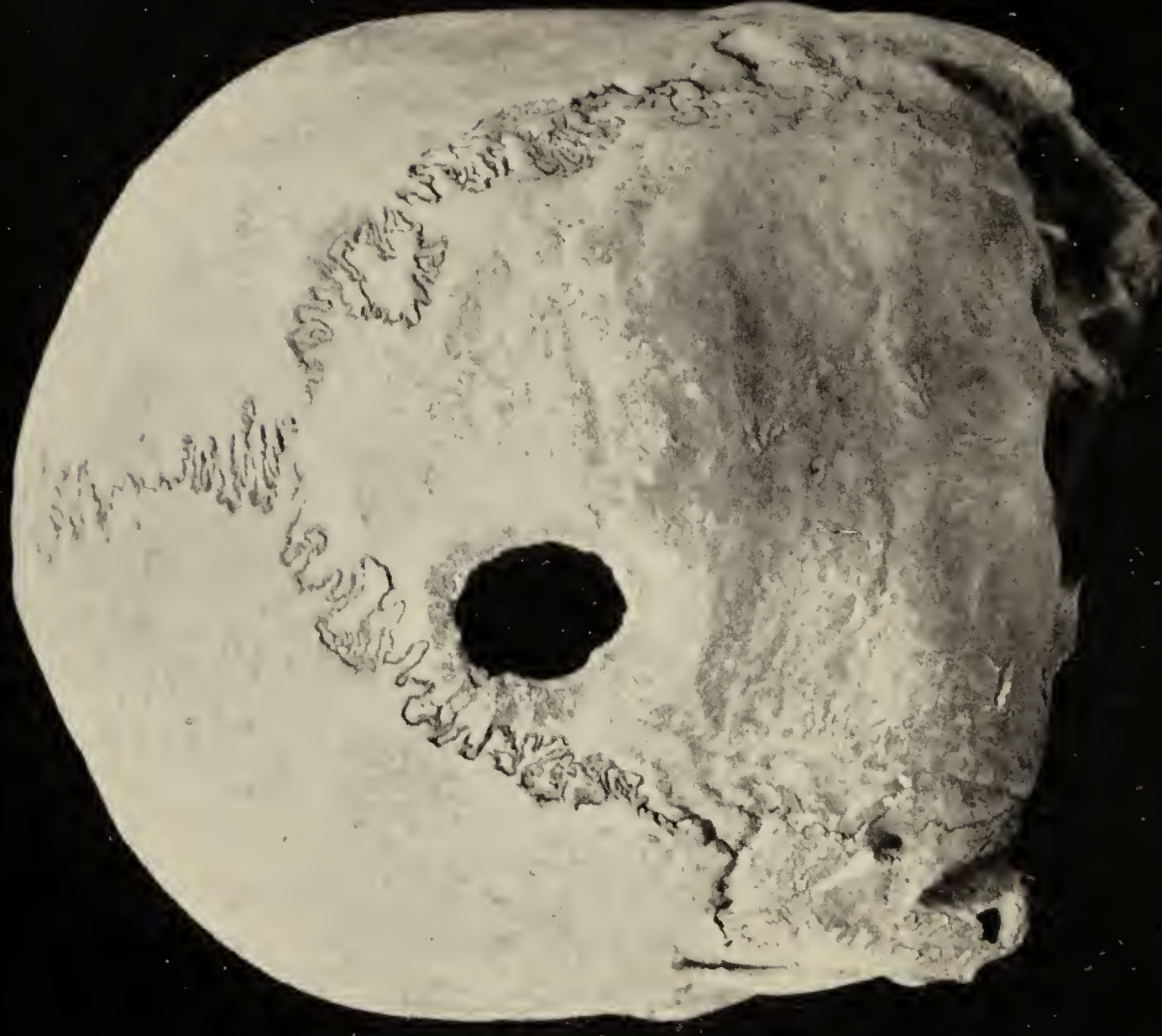




LEFT LATERAL ASPECT OF CRANIUM 7







POSTERIOR ASPECT OF CRANIUM 7







Of the two operations displayed, the clearer as regards *modus operandi* is high in the frontal bone, invading the metopic suture, and centering 30 mm. below the coronal. The aperture is approximately circular, averaging some 27 mm. in diameter, measured on the outer surface, and rather less than 20 mm. measured on the inner surface. While the marks of the instrument are indistinct, the general character of the incisions is fairly indicated. The most clearly defined incision is an approximately rectilinear cut 25 mm. long, defining the left side of the aperture, curving anteriorly toward the metopic suture, which it just reaches some 20 mm. beyond the point of sharpest curvature. The other side of the aperture is defined chiefly by two fractures, one of which apparently was located by an incision some 20 mm. in length just on the right of and parallel to the metopic suture. So far as preserved, the principal incision is V-shape in section, attenuating toward one extremity but becoming indefinite toward the other; and it seems to have been carried through the outer table throughout most of its length and around the sharper part of the curve, and also nearly or quite through the inner table about the middle part of its length; then, as the walls of the aperture indicate, an elevator was inserted and the button was broken out entire or, more probably, in fragments by leverage over the firm bone outside the region of cutting. Striae extending from the termini of the two horizontal incisions indicate slipping of the instrument, or preliminary exploratory cutting; and these, together with the features of the main incisions, bear the usual testimony as to the use of a single-point blunt instrument, apparently of stone. The extension and conformation of the cuts are best explained on the supposition that the operator occupied a rather low seat and held the head of the patient (sitting or reclining on the ground or floor facing toward the operator's right) between his knees, using his right hand for the cutting, and sometimes turning the head slightly as the work progressed. The sharp edges of bone, particularly in the outer table, were finally smoothed off, though whether intentionally by the operator or subsequently by reparative process is somewhat questionable; yet the condition of both tables and diploe indicate with practical certainty that the sufferer survived the operation for months or years. No trace of lesion antecedent to the operation appears, and the bone is so thick and the aperture so small as almost to prove that there could have been no antecedent depressed fracture or related injury.

The locus of the other and earlier operation is the upper left portion of the occipital, just invading the lambdoid suture. The aperture is elliptical, measuring 18 by 23 mm. between the narrowest portions of the walls. At this point the skull is somewhat eroded by weathering, and the margins, especially toward the lambdoid, are slightly crumbled; yet the state of preservation suffices to indicate long-continued reparative process whereby the bony margins were smoothed and rounded, the diploe completely obliterated, and all traces of instrumentation

eliminated. In a general way the operation would seem to have been similar to the later one in the anterior part of the head, though doubtless performed several years earlier. As in the later operation, traces of antecedent lesion are conspicuously absent, and the attendant features are hardly consistent with the supposition of considerable traumatic injury.

The usual long-healed grooves over the temples appear in the specimen, two of exceptional length on the right and two or three on the left; there are no other scars or abnormal features, save the vestigial preservation of the metopic suture.

#### CRANIUM 8

(*Plate XVI*)

Although fragmentary only, this specimen is well preserved, and represents a large and strong cranium, the bones averaging 5 mm. or more in thickness. The sagittal suture is almost completely ankylosed, and the lambdoid greatly obscured, indicating fully mature age. The specimen displays a well-defined artificial aperture in addition to a smaller opening, possibly artificial but more probably a pathologically persistent parietal foramen.

The undoubted operation was located on the top of the head, i. e., near the antero-superior angle of the right parietal, centering 28 mm. from the sagittal suture and 35 mm. from the coronal. The aperture is approximately circular, averaging 30 mm. measured on the outer surface and 27 mm. on the inner. The traces of primary instrumentation are indistinct; yet they appear to indicate careful manipulation of a blunt single-point cutting and grinding tool, held vertically on one side and obliquely on the other and worked with a short reciprocal or sawing motion in curvilinear fashion, in such manner as to define the circular aperture. The conformation of the cutting suggests an attitude of operator and position similar to that suggested by cranium 7, save that the patient faced toward the operator's left; the head was apparently rotated considerably as the cutting progressed, while the position of the tool, as held in the right hand, was somewhat oblique, undercutting slightly on the side of the aperture toward the operator's left, and overcutting considerably on the other side. It would seem that the random scratches due to slipping of the tool, particularly on the posterior and inferior sides of the opening, were subsequently ground or rasped away by rubbing with a rough tool which left fine but irregular scratches in the outer table. A few aberrant cuts extending some distance from the aperture remain; two of these, parallel to the sagittal suture, extend forward from the aperture, one for 15 mm. and the other for 22 mm. to the coronal suture, as shown in the reproduction. Despite the persistence of these marks, the character of the margins of both inner and outer tables indicates that the patient survived the operation, and that slow reparative changes, not however extending to material bony growth, supervened.







SUPERIOR ASPECT (INVERTED) OF CRANIUM 8, FROM HUAROCHIRI





ANTERIOR ASPECT OF CRANIUM 9, FROM HUAROCHIRI







LEFT LATERAL ASPECT OF CRANIUM 9







There is no certain indication of lesion antecedent to the operation, though a fracture, defining the anterior edge of the right parietal in the broken cranium, passes the sagittal suture and extends into the aperture; it is, however, probable that this fracture was long post-mortem and produced on collecting the specimen.

#### CRANIUM 9

(*Plates XVII, XVIII*)

The principal bones of this specimen are fairly preserved, though somewhat bleached. The skull is rather small and thinner than the mean of the collection, though the processes and attachments are strong; about the single artificial aperture it averages 3 mm. in thickness. The sagittal suture is nearly obliterated in the middle third of its length, though the other sutures are distinct, the condition on the whole indicating early middle age.

The operation displayed by the specimen was located in the middle of the left half of the frontal bone, centering about 45 mm. above the orbit; it is elliptical, with one flattened side, measuring about 16 by 25 mm. on the inner surface, or 19 by 33 mm. on the outer surface of the skull. The margins are somewhat weathered, rendering the testimony of the specimen concerning the operation and its consequences somewhat doubtful. On the whole, the form of the aperture and the features of the margin indicate that it was produced by a clumsy single-point instrument, such as a stone spearhead, rather deftly operated in such manner as to produce a curved incision describing nearly a semicircle, with the extremities more sharply curved and joined by a straight cut; the instrument being held nearly vertical while forming the sides of the contemplated aperture, but slanted toward the ends, either clumsily or to facilitate the insertion of an elevator. Apparently the edges of the aperture were afterward smoothed somewhat; yet the condition of the bone, including the obliteration of the diploe by local replacement, indicates considerable reparative process, extending to the growth of bony spicules, now largely removed by weathering and erosion. It is unquestionable that the operation was ante-mortem, and that the sufferer survived, probably for years.

While there is no clear indication of antecedent lesion, there is a faint line parallel with the superior side of the aperture and 3 or 4 mm. distant (which does not appear in the reproduction), possibly marking the limit of a small depressed fracture.

#### CRANIUM 10

(*Plates XIX, XX*)

This is a well-preserved skull, considerably stained with ocher or cave earth. It is small but strong, with the usual splendidly developed ligament attachments, and, though some 5 mm. thick, has been preserved in such manner as to be exceptionally light. Some of the sutures are

anched and partly obliterated and others distinct, while the teeth are fairly developed, except that one posterior molar is lacking and the other imperfect, the features collectively indicating middle age.

The operation displayed by this specimen is in the posterior angle of the right parietal, extending to both sagittal and lambdoid sutures. The aperture is rudely circular and 28 or 29 mm. in mean diameter. Although the bone is in excellent preservation, it is impossible to determine the manner in which the operation was performed, since all definite traces of instrumentation have been obliterated by reparative process, including the complete replacement of the diploe and the development of strong spicules of new bone pushing into the aperture. The most conspicuous of these spicules is that clearly shown in both reproductions at the lower side of the opening. The sharp angle immediately above also represents well-developed bony growth. While the record of the operation is thus obscure, it is nevertheless fairly if not finally evident that the operator proceeded in a manner unlike that represented in most or all of the preceding specimens. The conspicuous feature of the artificial work lies in the fact that the bone attenuates uniformly toward the edges of the aperture as if removed by scraping or grinding, perhaps with an edge or rasp-like side of considerable length. (This is well shown in plate XX.) There are, however, a few exploratory scratches, notably one extending forward from the upper margin of the grinding, 30 mm. from and nearly parallel with the sagittal suture.

No antecedent lesion can be detected, but it is certain that the patient survived the operation long, probably many years. The cranium displays three great grooves over either temple arranged in symmetric pairs.

#### CRANIUM 11

(*Plates XXI, XXII*)

Although somewhat bleached and weathered, this cranium is in excellent condition. The occiput is singularly flattened, particularly on the left, as shown imperfectly in the right aspect represented on plate XXII. There is some flattening also of the face, with an apparently abnormal shortening of the mandible. Two or three small interparietals occur. The bones are rather thin, ranging from  $2\frac{1}{2}$  to  $4\frac{1}{2}$  mm. The teeth are exceptionally mature for the collection, though the sutures remain distinct.

The operation for which the specimen is notable was performed near the center of the frontal bone, a little to the right of the median line, and extending from 37 mm. above the orbit to within 22 mm. of the coronal suture. The aperture is an elongated ellipse, 21 or 22 mm. in maximum width by 40 in length, measured on the feather edge of the inner table. In this case, too, all definite traces of instrumentation are lost, partly by weathering though chiefly by reparative process. The margins of both tables are rounded, the diploe is completely obliterated,







POSTERIOR ASPECT OF CRANIUM 10, FROM CUZCO



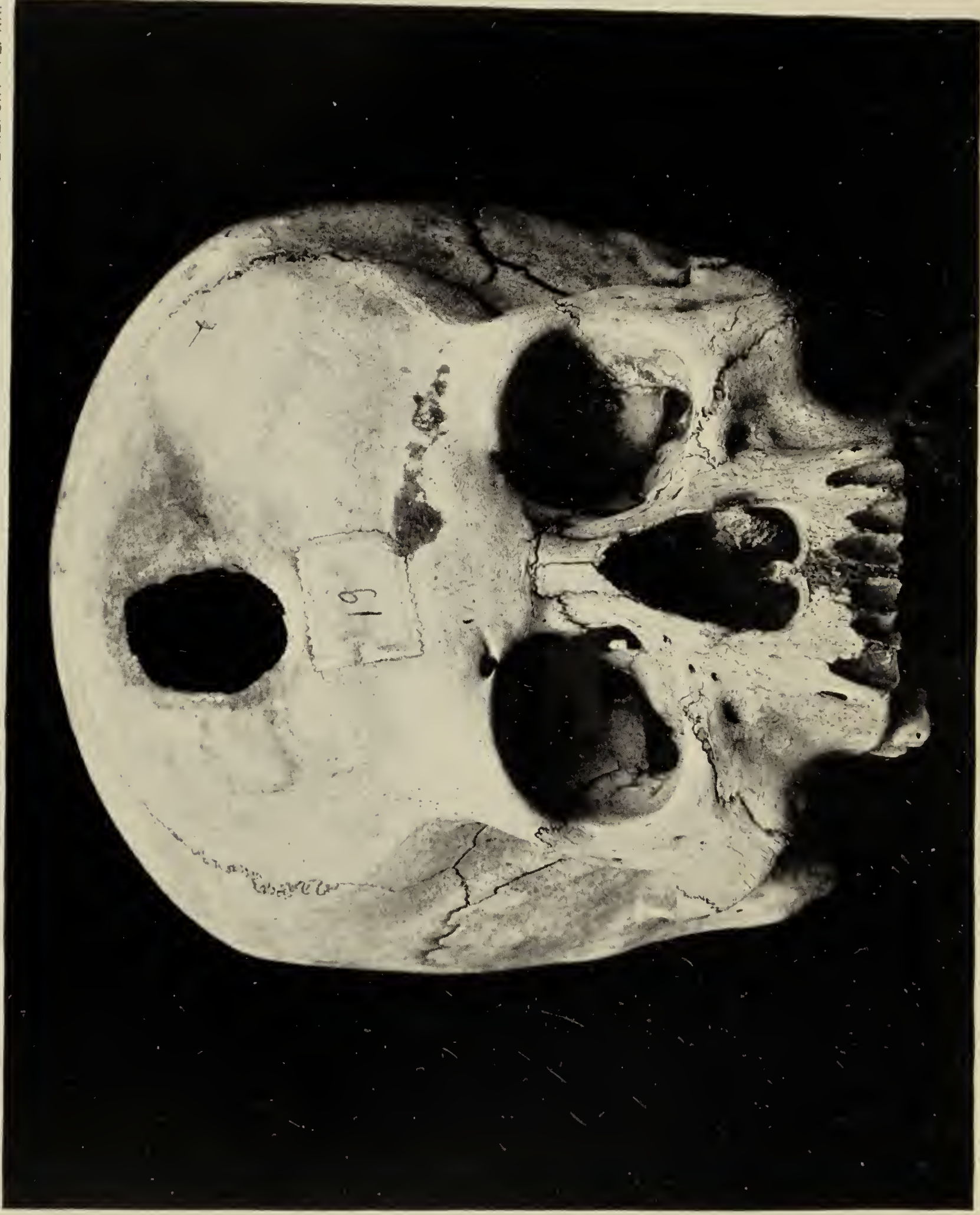




RIGHT LATERAL ASPECT OF CRANIUM 10







ANTERIOR ASPECT OF CRANIUM 11, FROM PACHACAMAC







RIGHT LATERAL ASPECT OF CRANIUM 11







and there are a few small spicules of new bone projecting into the aperture, notably a sharp point at the anterior extremity (shown clearly in plate XXI). So far as can be judged, the *modus operandi* was similar to that represented in cranium 9, with subsequent grinding or rasping of the outer table to remove the raw edges; yet it is quite possible that the aperture was made wholly by scraping.

No trace of lesion antecedent to the operation remains. It is clear that the sufferer lived for some time, certainly months and probably years, after the treatment. The usual vertical cut in the bone appears above the right temple.

#### CRANIUM 12

(*Plates XXIII, XXIV*)

Although nearly white, as if bleached, this cranium was taken from a fairly well mummified body, and fragments of ligaments and other tissues remain, while the bone is fatty. The specimen is small, rather light and thin, somewhat delicate in outline, with less conspicuously strong attachments than most of the collection; it is one of two crania suspected to be feminine. The teeth are nearly mature and the sutures somewhat obscured; there are over half a dozen little interparietals.

The rather complex operations were located about the center of the superior side of the occipital. The principal aperture is rudely circular, interrupted by an irregular salient, and averages perhaps 26 mm. in diameter; the next in size is an irregular oblong about 8 by 12 mm., and the smallest is an approximate circle some 6 mm. in diameter. The marks of instrumentation are rather indefinite, and are practically absent about most of the margin of the largest aperture. So far as can be judged, the initial operation was begun by a curvilinear incision extending from near the center of the occiput upward and forward nearly to the lambdoid suture, where it was curved sharply and afterward connected with another curvilinear incision defining the medio-superior side of the largest opening. It would seem probable that the principal button was then removed by the aid of an elevator, leaving a ragged margin on the median side, and that the edges of the outer table were then scraped smooth and neatly beveled. Afterward considerable physiologic action apparently supervened, whereby the tool marks were obliterated, while the diploe was solidified and the cut surface brought into the condition of normal bony surface, the period of reparation being probably months, possibly years. Then ensued the later operation, beginning with a transverse rectilinear incision some 40 mm. long extending from near the center of the occiput to the inferior margin of the antecedent aperture and passing into extensive scraping of the bone, thence upward nearly to the suture and rightward to the large opening. Further than this, the *modus operandi* seems still more doubtful, though minute scratches, as well as the general conformation, would indicate that the oblong aperture was produced by scraping.

There is nothing clearly to indicate how the smallest aperture was produced, though it has every appearance of artificial origin, and there are decisive indications, in the preservation of the tool marks and the retention of normal character by the diploe, that both of the medial openings are much more recent than the large one; indeed, it is doubtful whether the sufferer survived the later operation, and the conformation of the smallest aperture indicates pretty clearly that the underlying tissues were invaded so seriously as to produce death. In general, the operations display some evidence of both rectilinear and curvilinear incisions, such as those characteristic of the earlier members of the series, with definite indications of subsequent scraping or grinding.

There is no definite indication of antecedent lesion; although the general appearance of the bone and the distribution of the openings vaguely suggest a diseased, possibly leprous or syphilitic, condition, the suggestion vanishes when the firm, sound bone is examined closely. Near the antero-inferior angle of the right parietal there is a darkened and evidently abnormal tract, more conspicuous in plate XXIV than in the specimen, perhaps the trace of local osteitis induced by a blow; there is also a dent, with some crushing of the bone, 35 mm. above the left orbit, and one of the customary vertical grooves appears over the right temple.

#### CRANIUM 13

(*Plate XXV*)

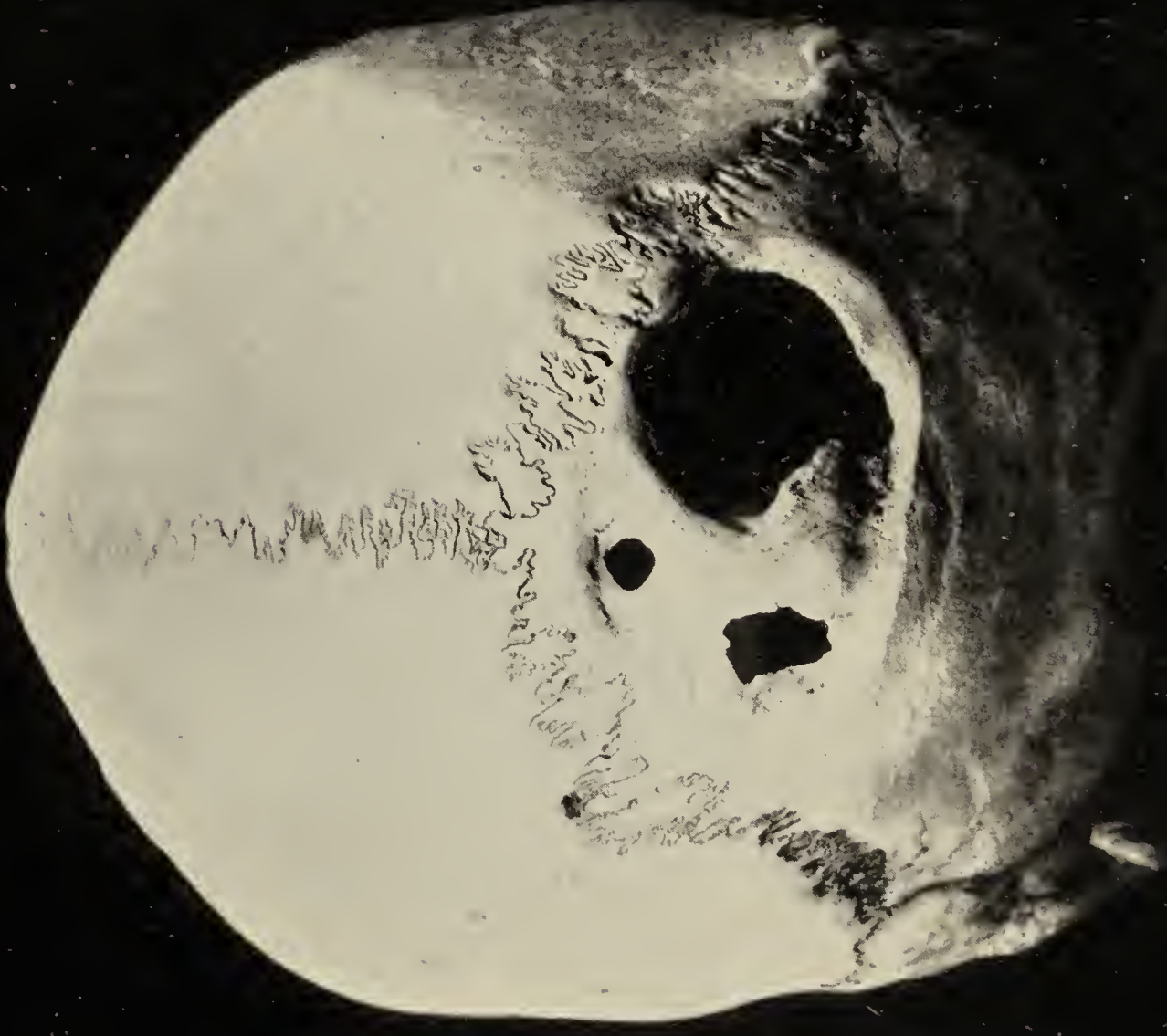
This specimen is perhaps the least satisfactory of the series, chiefly because of the weathering and erosion to which it has been subjected. It is small but thick, averaging probably 6 or 7 mm., with the usual prominent occiput and attachments. The teeth are fairly developed and ankylosis is well advanced, indicating maturity; as usual, there are several small interparietals.

The more significant of the two operations displayed by the specimen was performed in the top of the head, involving the sagittal suture, and apparently extending also into or across the coronal, though this is rendered somewhat doubtful by weathering and a recent fracture. This aperture is oblong, 12 mm. wide and (probably) 20 mm. or more long. No trace of instrumentation remains; the margins are thoroughly rounded and the diploe is completely obliterated, giving an air of antiquity to the opening; undoubtedly the sufferer survived the operation for many years, despite the infraction of a modern rule against trephining over sutures.

The locus of the second operation was the upper part of the left parietal, centering about 40 mm. from the earlier one, and about the same distance from the sagittal and coronal sutures. The aperture is oval, about 17 mm. in breadth by 22 in length. The surrounding bone is somewhat eroded, yet enough of the original surface remains to indicate clearly a reparative rounding by physiologic process, similar







POSTERIOR ASPECT OF CRANIUM 12, FROM CUZCO (DOUBLE-TREPHINED)







RIGHT LATERAL ASPECT OF CRANIUM 12







SUPERIOR ASPECT OF CRANIUM 13, FROM CUZCO (DOUBLE-TREPHINED)







to, though less advanced than in connection with the other aperture in the same cranium, and quite similar in character and advancement to that displayed by the earlier operation in cranium 7. Both tables display short and small knobs or spicules of reparative growth, and fully half of the margin of the inner table shows the peculiar conformation and coloration characteristic of such growth, as may clearly be seen in the reproduction. The diploe is obliterated on the anterior side of the aperture; on the posterior side it was partly absorbed (though the spongy texture was modified through replacement as in most of the examples), leaving a groove 3 mm. wide and 2 to 3 mm. deep between the tables. So extensive are the subsequent physiologic modifications that all trace of instrumentation has been obliterated. Evidently the sufferer survived this operation, also, for a considerable period, probably a number of years.

In neither case is there the slightest trace of antecedent lesion. It may be noted that the outer table about the apertures, particularly the later, is somewhat rough as to surface and vesicular in texture, probably by reason of physiologic and post-mortem processes initiated by the operation, but possibly because of caries.

For purposes of comparison and to complete, so far as practicable, the illustration of trephined crania from Peru, the eight specimens illustrated on plates XXVI and XXVII are introduced. The reproductions are half-tone engravings from small photographs obtained by Dr Muñiz. The specimens are preserved in the museum at Cuzco.

Figures *a* and *b*, plate XXVI, represent crania penetrated by large and irregular apertures, showing no definite traces of instrumentation. In figure *a* the margins are jagged, suggesting the enlargement of an original aperture by the use of a vigorously applied elevator fulcrumed on the opposite margin; there is no trace of subsequent growth, and consequently nothing to indicate the purpose of the operation, or whether it was late ante-mortem or post-mortem. Similarly in figure *b*, the irregular form and absence of incisions suggest extensive use of the elevator; while the rounded margin, particularly on the anterior side of the aperture, indicates subsequent reparative process, and thus shows that the operation was ante-mortem. In figures *c* and *d* (plate XXVI), in like manner, all trace of instrumentation has been obliterated by subsequent growth, which in both cases (particularly the latter) is extensive and characteristic. The operation represented in figure *c* involved the coronal suture. In figure *d*, in less measure in figure *c*, and to a still less extent in figure *b*, there are suggestions of malformation or of general pathologic condition resulting in necrosis, followed by the reparative process indicated; but the suggestion does not demand serious consideration, partly because of its improbability in view of the characteristics displayed by the Muñiz collection, partly because the question could be set at rest only by examination of the crania themselves.



The specimen illustrated in figure *a*, plate XXVII, displays two apertures, both of somewhat doubtful character. One is an elongated slot, the outline and sharp edges of which suggest the use of a metal instrument; but the method in which the operation was performed can not be determined from engraving or photograph. The cranium represented in figure *b* exemplifies a mode of operation distinct from any of those indicated by the Muñiz collection. In one case there are three rather small perforations placed in the form of a triangle. The perforations suggest the use of a drilling or boring instrument, perhaps similar to the brima used by the Kabyle, and their arrangement suggests that the drilling was followed by the use of a strong elevator and the breaking out of the fragment described by the perforations, also after the manner of the Kabyle. The large aperture made above the right orbit in the same specimen would appear to have been produced in this way. In this manner, too, the huge aperture in the specimen shown in figure *a*, plate XXVI, might have been produced. The reproduction suggests the employment of rude metal instruments, although the operation is of no higher order than those revealed in the Muñiz collection, and although the drilling and elevating might easily have been effected by stone perforators and elevators of bone or wood. The operations represented in figure *b* and the elongated opening shown in figure *a* (plate XXVII) reveal no indications of subsequent growth, and may accordingly have been late ante-mortem or post-mortem.

The figures *c* and *d*, in plate XXVII, represent two approximately circular operations, comparable with several of those revealed in the Muñiz series. Viewed in the light of these examples, it would appear that both were performed by means of somewhat irregular curved incisions, followed by the use of the elevator, and that the margins were subsequently beveled by rasping or scraping; it would appear also that both individuals long survived the operation, as indicated by reparative growth and rounding of surface, and the partial obliteration of the diploe.

#### CRANIUM 14

(*Plates XXVIII, XXIX*)

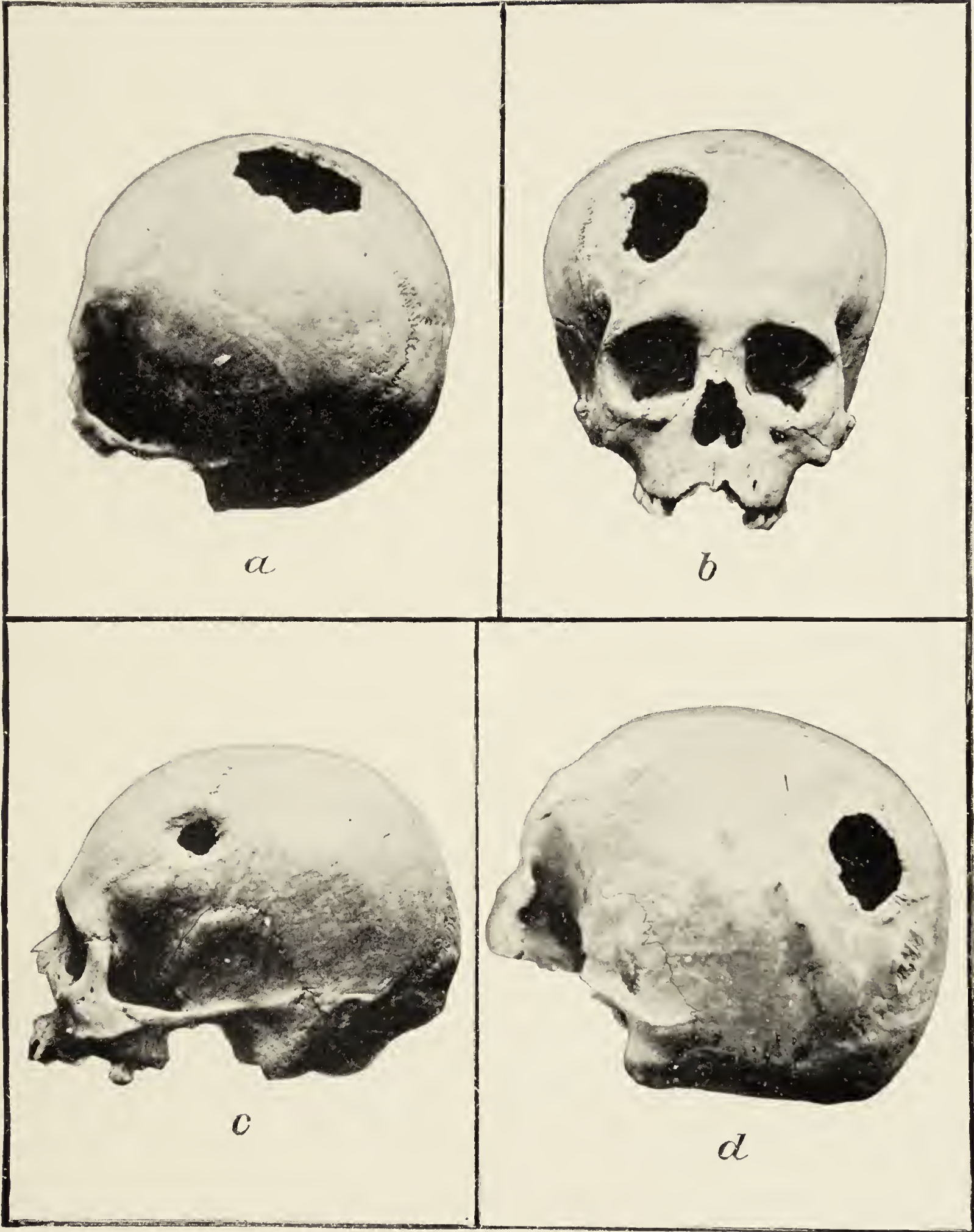
This specimen is a mummified head, with most of the scalp and facial integument and some of the hair remaining. The mature development of the teeth and the condition of the small portion of the sutures visible indicate maturity; the hair is not gray. The tendons are well developed; the skull is thinner than the average for the collection, measuring about 3 mm. at the point of operation.

The single incomplete operation displayed by the specimen is remarkably instructive. It was located by a depressed fracture in the left side of the frontal bone, centering 45 mm. above the orbit, and extending just to the coronal suture; in this fracture a section of both tables 15 by 20 mm. was forced inward, hinging at the left, but completely









FOUR CRANIA PRESERVED IN MUSEUM AT CUZCO





FOUR CRANIA PRESERVED IN THE MUSEUM AT CUZCO





severed on the lower side, around the median end, and part of the way around the upper margin; this tongue of bone is itself indented and warped, evidently by the force of the blow producing the fracture; and two fissures partially crossing its base nearly separate it from the uninjured bone. The rupturing of the inner table was quite as complete as that of the outer; the inner table was split and torn apart beneath the depressed tongue, and a sliver 15 mm. long and 10 mm. wide remains attached at the lower anterior side of the wound. Apparently a narrow zone of the outer table has disappeared from this portion of the wound, since the depressed tongue is 1 or 2 mm. narrower than the aperture; and the antero-superior extremity of the tongue has also disappeared, leaving a clear aperture of about 5 by 10 mm. In general the wound is more extensive on the inner surface of the cranium than on the outer, for, as is usual in case of depressed fracture, the margins are undercut, the tables separating somewhat on the diploe. The features of this wound are slightly masked by the marks produced in the unfinished operation.

The indubitable features of the operation are three principal incisions, with a number of minor scratches. The most prominent incision is nearly horizontal, traversing the upper part of the wound; it is 30 mm. in length and penetrates both tables of the bone for a length of 10 mm. immediately above the wound. Its anterior extremity divides into two strong and several feeble scratches, each evidently made by a single moderately sharp point; the deeper portions are V-shape in section, and the wall of the incision above the wound shows parallel striation, as if ground by a rough surface; in short, the incision is precisely such as would be produced by a rather sharp stone knife or spear-head, worked reciprocally with considerable pressure, and the associated scratches are such as would almost inevitably be produced by the slipping of such an instrument in the hands of a clumsy operator at the beginning of the operation. The second incision starts from the anterior extremity of the first, at an angle of about 60 degrees, and skirts the lower margin of the fracture for half its length, i. e., for about 19 mm. It is a miniature homologue of the incisions displayed in cranium 1 and other specimens, V-shape in section, deepest and broadest toward the middle, narrowing and shallowing to mere scratches at the extremities; in this case, too, there are a few scratches, evidently due to the slipping of the instrument. For a length of 5 or 6 mm. it enters the diploe; it does not penetrate the inner table. The third incision crosses the first near its posterior extremity, at an angle of about 60 degrees, the three being so placed as to describe an equilateral triangle coinciding with the anterior third of the fracture. This incision is 11 mm. in length, projecting 6 mm. beyond the first incision (which itself projects 3 or 4 mm. beyond this, though not clearly shown to do so in the reproduction). It penetrates both tables of the skull just above the wound, and terminates abruptly at the fracture, the relations being

such as to prove conclusively that the fracture preceded the incision. In this case, too, there are irregular scratches about the extremity of the incision, showing slipping of the tool. The terminus of a fourth incision or series of incisions appears near the anterior extremity of the wound, approaching the central part of the second incision. These deep scratches were apparently made on a hinged fragment of the bone connecting this part of the skull with the principal depressed tongue; and it is evident, first, that they were not made until after the fracture, and, second, that a fragment of bone has disappeared since they were made. In addition to these definite incisions, there is a shallow cut or scratch 15 mm. long, nearly parallel with the second incision, extending from the anterior extremity of the wound toward the median line; it is indistinctly shown in plate XXIX.

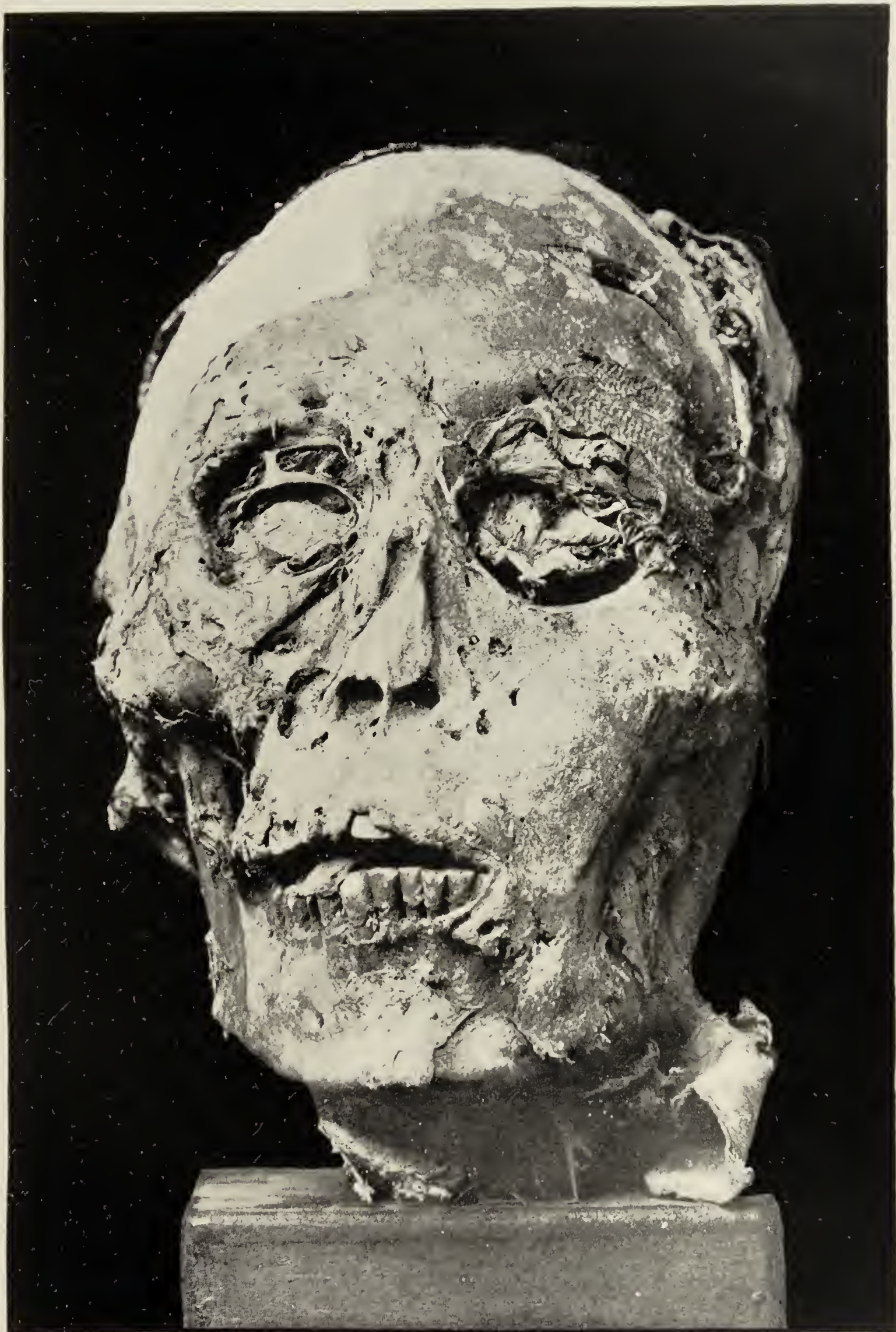
It is noteworthy that the bone was stained and the periosteum modified over a tract considerably larger than that of the fracture (though this is not clearly indicated in the reproduction). On the lower side of the wound this tract is not clearly defined, though its margin seems to be close to that of the fracture; but on the upper and posterior sides it forms a zone 10 to 15 mm. wide, semicircumscribing the wound. This feature is especially significant in connection with the local discoloration and modification of several other crania, notably 1, 2, and 5. It would appear to represent extension of the injury to the soft tissue, perhaps resulting in periostosteitis, or death and exceptionally rapid post-mortem decomposition in advance of mummification.

The sequence of events and movements in the history of the case is indicated by this specimen with considerable clearness and certainty. It is evident that the first event was the production of the wound by impact of a hard object (perhaps a sling stone or club spike). It seems probable that several hours then passed without treatment, during which local inflammation developed and extended to the periosteum. Then the operation was commenced, apparently by opening the scalp and laying bare the bone (since otherwise the subsequent removal of bony splinters could hardly have taken place). Then it would appear that a short incision (the fourth of the foregoing description) was made, whereby one or two fragments of bone were liberated and removed from the anterior and lower margins of the wound. Then the principal incision skirting the upper side of the wound was made, and another splinter partly liberated; and, to dissever this splinter, the short incision above the depressed tongue was then produced, when the fragment was broken out by means of an elevator, leaving a small irregular projection of the inner table just beneath the intersection of the two incisions. It would appear that the anterior incision was then started for the purpose of removing the rough edges of the bone and giving access to the conspicuous sliver of the inner table at the lower side of the fragment. This incision was soon abandoned, and the operation discontinued. There is nothing to indicate whether the scalp was









ANTERIOR ASPECT OF CRANIUM 14, FROM HUAROCHIRI









LEFT LATERO-ANTERIOR ASPECT OF CRANIUM 14







restored, and everything to indicate that death supervened about this stage.

It may be observed that this specimen displays decided facial distortion, the mouth, nose, and tongue being strongly drawn toward the right. Whether this distortion was in any way connected with the wound or the operation is an interesting question, but one that need not be pursued for the present, since it would seem impossible to arrive at certain or useful results.

#### CRANIUM 15

(*Plates XXX-XXXII*)

The specimen is in excellent condition, the bones being perfectly preserved, and a considerable part of the scalp and other tissues remaining. The skull is strong, with the usual rugose attachments. Its thickness varies from  $3\frac{1}{2}$  to 5 mm. about the single artificial aperture. The teeth are only fairly mature and ankylosis of the sutures is but moderately advanced, indicating that the individual died in his prime.

The incomplete operation, which reveals the methods of the operator with gratifying clearness, was located by a fracture near the posterior angle of the left parietal, extending to within 15 mm. of the sagittal and lambdoid sutures. The initial wound depressed a tract of bone about 47 mm. long and rather over 20 mm. wide, measured on the outer table. Toward the sagittal suture and along the lower margin the inner table is undercut 2 to 5 mm. The indications are that the bone was completely severed more than halfway around the oblong aperture, remaining hinged at the upper and anterior margins. In addition the outer table was cracked concentrically with the central part of the wound, parallel with the upper margin and some 10 mm. from it, as shown clearly in plate XXXII. The instrumentation comprised three definite incisions. The most conspicuous of these is an approximately rectilinear cut 37 mm. long, skirting the upper part of the fracture and penetrating the inner table for a distance of 12 mm. The projecting extremities are of the usual V-shape section and termination, and longitudinal striæ appear in the remaining wall of the incision, showing that the instrument was of the kind indicated in other operations. The second incision in extent describes the upper and posterior side of the aperture, originating near the extremity of the first incision. It is 27 mm. long, extending somewhat farther in a narrow scratch, and penetrating the inner table for 5 or 6 mm. near its anterior termination. The third incision describes a part of the anterior margin of the aperture, crossing the extremity of the principal incision. It is about 20 mm. long, but extended farther on the tongue of bone subsequently removed. A few shallow cuts are placed obliquely to this incision, originating at the intersection of this with the first incision and extending directly downward. These marks appear to represent a preliminary or exploratory cutting, which was abandoned when the deeper

and approximately parallel incision was outlined. In addition there are several shallow notches in the lower margin of the aperture near the anterior extremity, evidently made by striking the instrument against the outer table while sawing across the base of the depressed tongue, either in making the third incision or (more probably) in making a nearly parallel incision traversing the tongue in a somewhat more nearly horizontal direction. All of the incisions and scratches were apparently made by the same tool.

The sequence represented by the operation is indicated with considerable clearness. Initially there was a large depressed fracture with some adjacent cracking of the bone, the principal depressed tract being in the form of a tongue hinged at the anterior and upper sides, but completely severed more than halfway around. Three or more incisions were made in such manner as to divide the hinge, and in making a part of them the tool was reciprocated on the depressed bone in such manner as to leave its marks on the free margin. When the incisions were fairly advanced, an elevator was used and the depressed tongue was forced out, leaving projecting edges of the inner table on the upper margin, and this operation was performed with such vigor that the anterior portion of the hinge passed beyond the nearly vertical incision and invaded the uninjured bone, breaking through both tables and leaving the inner projecting beyond the outer. At this point the operation was discontinued, presumptively by reason of the death of the victim; the rough edges were not smoothed, and there is not the slightest trace of subsequent growth—indeed, the invasion of the cerebral tissues by the tip of the clumsily applied instrument would have been almost necessarily fatal. In this specimen there is no indication of local inflammation.

Taken together, crania 14 and 15 appear to represent somewhat different stages in precisely parallel operations. In cranium 14 the treatment was abandoned after the removal of a few fragments and splinters of bone, but before the removal of the principal tongue, while in cranium 15 it was abandoned immediately after removing the tongue or button.

Cranium 15 displays the vertical grooves over the temples, one on either side, with a few smaller marks. In addition there is a prominent scar of a practically healed wound a little to the left of the center of the upper margin of the frontal bone. The wound was evidently produced by a blow from a rather blunt edge, transverse to the median line, directed downward and forward so as to glance forward; the bone is indented and bruised, forming a transverse trough (15 mm. below the coronal suture) 5 or 6 mm. broad and 17 mm. long; below, the bone bulges slightly, and the lower side of the ridge is partly defined by a curved fracture of the outer table 18 mm. long. The edges of the fracture are knit, and there are other indications that the wound was practically recovered before death.



restored, and everything to indicate that death supervened about this stage.

It may be observed that this specimen displays decided facial distortion, the mouth, nose, and tongue being strongly drawn toward the right. Whether this distortion was in any way connected with the wound or the operation is an interesting question, but one that need not be pursued for the present, since it would seem impossible to arrive at certain or useful results.

#### CRANIUM 15

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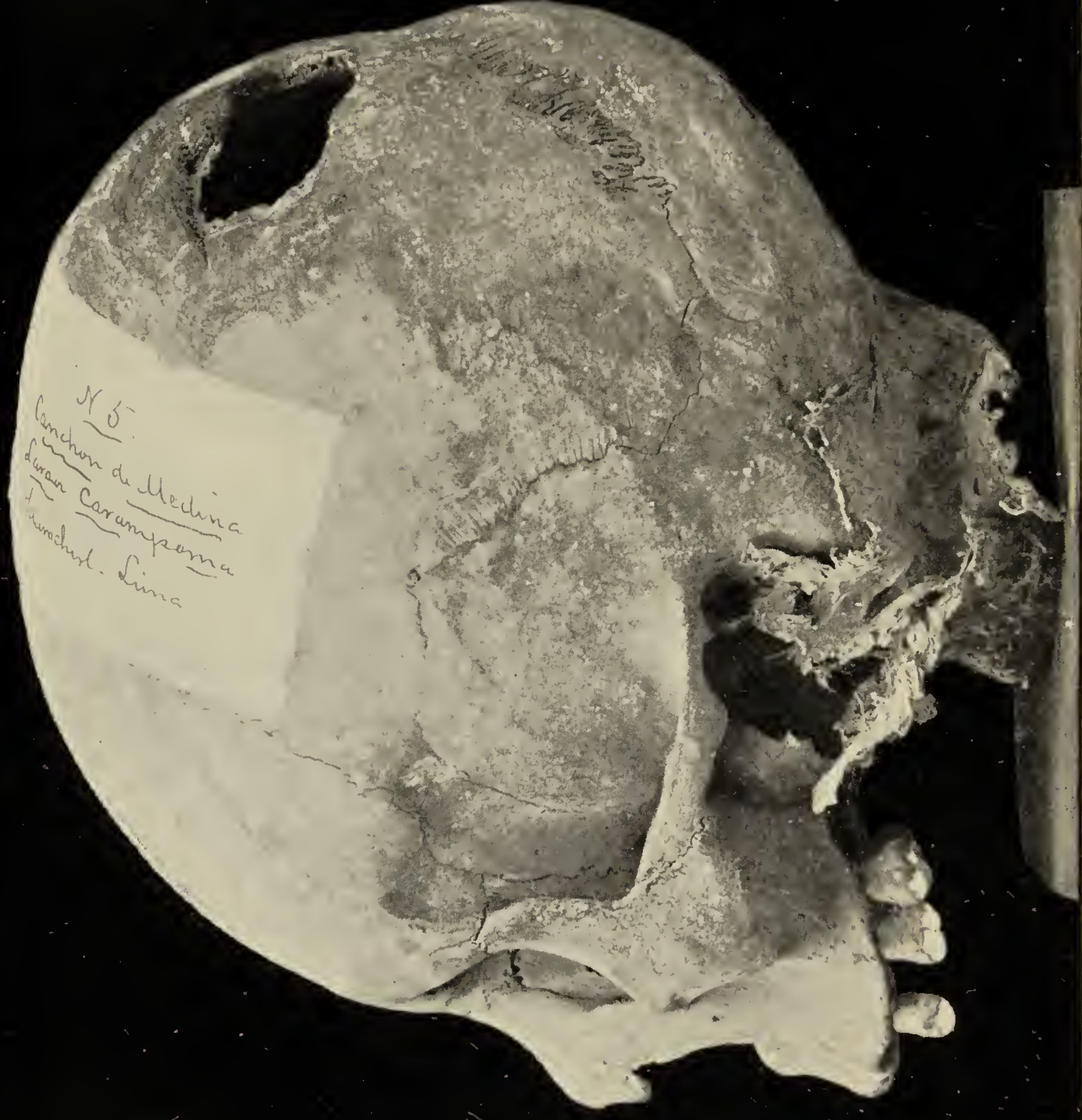




SUPERIOR ASPECT OF CRANIUM 15, FROM HUAROCHIRI







N 5.  
Canchon de Medina  
Carampoma  
Turochyl. Lima

LEFT LATERAL ASPECT OF CRANIUM 15







LEFT LATERO-POSTERO-SUPERIOR ASPECT OF CRANIUM 15







## CRANIUM 16

*(Plates XXXIII, XXXIV)*

This is a mummified head, in excellent condition for examination, and of special interest in that it reveals in part the incisions through the scalp made in connection with the principal operation. The skull is one of the largest of the series, with the customary rugose attachments and stout tendons. The teeth are fairly mature (the left posterior molar is lacking), indicating early maturity. In addition to the lesions connected with the operation, there is a deep scratch on the left side of the frontal bone, extending from 32 to 57 mm. above the orbit, and an extensive scar, some 30 mm. wide by 50 high, on the right side of the same bone, extending from the coronal suture halfway to the orbit, together with a few minor scratches; all of these marks apparently recording recovered wounds.

The complex and elaborate operation was located by an extensive wound, chiefly a linear fracture, extending from the median line of the occipital through the lower angle of the right parietal to the temporo-parietal suture, along this suture for 20 mm., thence obliquely downward through the temporal bone to a point just within the zygoma, and thence upward and forward entirely across the temporal bone and half way to the margin of the left orbit; the fracture being 155 mm. in length measured directly on the surface of the skull, and about 200 mm. measured along its meandering course. The incision in the scalp began in the center of the back-head, and was carried well down over the occipital to a point apparently somewhat below the extremity of the fracture, and thence along the fracture to a point on the temporal bone near the posterior margin. The tissues were then apparently pushed aside and crumpled into irregular masses, that on the right of the incision being particularly thick. Work was then begun on the bone, apparently in random fashion; it would seem probable that the first incisions were the three nearly vertical cuts in the occipital. The deepest of these is about 37 mm. in length, and is carried into the diploe without penetrating the inner table. It is oblique V-shape in cross-section, with the usual attenuated extremities, the lower revealing a number of scratches. Parallel with it is a shallow incision of similar character, 22 mm. long and perhaps 2 mm. deep, not penetrating the outer table. Nearly parallel with these is a similar incision 35 mm. long and 3 mm. deep, just penetrating the outer table in its center. The upper extremity curves rather sharply to the left (though this does not clearly appear in plate XXXIV), while the lower extremity divides into deep scratches of the usual character, also veering toward the left. There is no indication that these deflections toward the extremities of the incision were intentional, and everything to indicate that they represented a series of slips of the tool occasioned by inequalities in the surface of the bone. Evidently these incisions were exploratory, and

were abandoned; since the last described just intersects the extremity of the fracture, which it might have revealed to the operator, it seems probable that the line of exploration was then turned toward the right along the fracture. Thirty-five mm. from the last incision there is an irregularly circular aperture, averaging 9 or 10 mm. in diameter, produced by scraping. This process extended over an area 25 or 30 mm. across, over most of which the outer table and diploe are removed and the inner table reduced to paper-like thinness. Thence a series of scratches and striæ, as if produced by scraping with a rather blunt tip or grinding with an irregularly rough surface, follow the fracture to and a little way across the lambdoid suture. At the intersection of the fracture with this suture the bone is gouged and scraped to a depth of 4 or 5 mm., or through the outer table and diploe. Thence several narrow scratches pass horizontally across the lower portion of the parietal, terminating about the temporo-parietal suture, beyond which the operation seems not to have been carried (these scratches are but indistinctly shown in the reproduction, plate XXXIII).

The sequence of events and movements in the case may be determined from the specimen with considerable certainty. The initial incident was apparently a blow or shock producing the linear fracture; and, while there is some doubt as to the character of the shock, and also as to the point of impact assuming it to have been a blow, it seems probable that the wound centered about the intersection of the fracture with the lambdoid suture, where the bone is depressed and where the character of the subsequent operation suggests that the outer table was crushed; and the fracture appears to be such as might have been produced by a violent blow at this point. It seems certain that this wound antedated the incision in the scalp, and that this incision was largely exploratory, since it was inaccurately located; and it seems probable that in the early stages the operation on the bone was random. In like manner it seems certain that the operation was abandoned incomplete; for not only is there no indication of finish in the work on the bone, but the scalp remained open when the victim was transferred from the presumptive battlefield to the cemetery; it is certain that he did not survive.

On the whole it appears impossible to regard the operation displayed by this specimen in any other light than as a crude, clumsy attempt, with rude tools, to explore or perhaps to treat a serious wound; and it is unquestionable that either the initial wound or the treatment proved fatal before the operation was complete. It can not, of course, be considered certain that the operation was not early post-mortem, but there is absolutely nothing to indicate this date; and not even the lowliest mind could have designed the cuts and scratches displayed by the bone for the purpose of obtaining portions of the skull for amulets or for any purpose. There is, of course, a possibility that the operation represents a post-mortem examination; but there is neither evidence nor presumption in favor of this supposition.



## CRANIUM 16

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This is a mummified head, in excellent condition for examination, and of special interest in that it reveals in part the incisions through the scalp made in connection with the principal operation. The skull is one of the largest of the series, with the customary rugose attachments and stout tendons. The teeth are fairly mature (the left posterior molar is lacking), indicating early maturity. In addition to the lesions connected with the operation, there is a deep scratch on the left side of the frontal bone, extending from 32 to 57 mm. above the orbit, and an extensive scar, some 30 mm. wide by 50 high, on the right side of the same bone, extending from the coronal suture halfway to the orbit, together with a few minor scratches; all of these marks apparently recording recovered wounds.

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RIGHT LATERAL ASPECT OF CRANIUM 16, FROM HUAROCHIRI







POSTERO-INFERIOR ASPECT OF CRANIUM 16







## CRANIUM 17

*(Plates XXXV, XXXVI)*

This is a mummified head, with the scalp remaining on the right side back of the coronal suture and over half of the occiput, while shreds of tissue remain elsewhere; the bones are perfectly preserved and fatty throughout. The skull is hardly so thick and strong as the average of the collection, though the attachments are rugose. The teeth are well developed (the left posterior molar is lacking) and the sutures fairly united, indicating rather early maturity; two interparietal bones (the smaller clearly shown in plate XXXV) interrupt the lambdoid.

The specimen displays a wound and two or three associated operations on the left side. The wound is an irregular splintered fracture, apparently centering just below a point about midlength of the temporo-parietal suture, and 30 or 35 mm. above the auricular meatus. The principal fissure traverses the temporal bone, as shown in plate XXXV, and can be traced in the auricular opening fully 30 mm.; a curvilinear crack some 30 mm. in length crosses this fissure at a large angle 12 mm. above the origin of the zygoma, dying out anteriorly but extending to the suture posteriorly; the third line of fracture evidently coincided with the suture for a distance of some 40 mm.; and a fourth apparently defined the lower margin of the irregular aperture for a length of somewhat over 30 mm. In addition there are traces of another radial fissure extending upward and backward from the central point for a distance of 35 mm.; it defines the upper margin of the triangular fragment loosened by the curvilinear crack and the fracture along the suture, divides the bridge of bone below the circular aperture, and appears in the specimen (and faintly in the reproduction) on the upper posterior side of this aperture. About the center of the wound the bone is considerably depressed.

There were three measurably distinct operations evidently located by the wound. The principal operation was that represented by the approximately circular aperture, which averages 19 mm. in diameter. All about this opening traces of instrumentation appear. The bone is striated in various directions, but for the most part concentrically about the aperture, showing that the operation was finished by scraping or rasping, though whether with or without antecedent incision and elevation can not certainly be determined. On the posterior side the bone is scraped quite thin, though on the anterior side most of the thickness of the inner table forms the margin and is cut through in a nearly vertical direction, showing that here at least there was curvilinear cutting, perhaps subsequent to the scraping. The general appearance of the opening and margins suggests that the operation was completed to the satisfaction of the operator; but the absence of reparative growth and the distinct preservation of the striae produced by rasping prove that the victim did not long survive.

The second aperture would seem to have been produced by a single operation, probably subsequent to the principal one. It was evidently begun by a rectilinear incision of the usual character, commencing at a point over the temporo-parietal suture (subsequently removed by the conspicuous canoe-shape incision) and below the main aperture, and extending thence forward at least 15 mm. to the main vertical fissure and probably somewhat farther. It was not carried through the bone. There are indications that when the bone was weakened by this incision, an elevator was used to break out two or more fragments, thus producing the triangular aperture. Jagged projections of the inner portion of the bone remained and were not removed, but the outer edges were smoothed by rasping or scraping.

The next operation or step produced a single rectilinear incision 35 mm. in length, 5 mm. wide at the center measured on the outer surface, of the usual V-shape section and terminations, penetrating the bone for a length of 11 mm. and a width of 2 mm. at the center, thus indicating that the instrument invaded the intracranial tissues and probably brought the trials of the victim to an end.

In addition to these definite operations there are several significant scratches, apparently exploratory. The most conspicuous are three or four parallel cuts, the longest 25 mm. in length, extending upward and backward from a point 10 mm. beyond the postero-superior margin of the principal aperture, in a direction approximately parallel with the radial fracture removed in making this aperture (the principal scratch of this series appearing in plate XXXV). Appearances indicate that these scratches originally extended farther downward and forward, and that their extremities were obliterated by the subsequent rasping. A single scratch extends almost directly backward from a point 15 mm. back of the main aperture for a distance of 6 or 7 mm., almost intersecting the upper extremity of a rough groove extending downward 17 mm., and crossing the posterior extremity of the principal rectilinear cut. Two rather conspicuous grooves appear downward and forward from the circular aperture; the more definite extends from the bridge below this aperture backward to the center of the main rectilinear incision. Along the suture below this incision there are conspicuous transverse scratches produced by scraping, rasping, or grinding with a rough edge or surface; and similar marks cross the curvilinear crack forward to the origin of the zygoma, where they unite with the striae connected with the main operation. The most remote traces of instrumentation are two parallel cuts in the bone just below the temporo-parietal suture, 10 mm. from its union with the lambdoid. (Only one of these marks appears in the reproduction.)

The indications of sequence in the operation are somewhat indefinite, though it seems certain that the instrumentation succeeded, and was located by, the wound. It would appear that on dividing and pushing aside the scalp (after the manner indicated by cranium 16), the operator



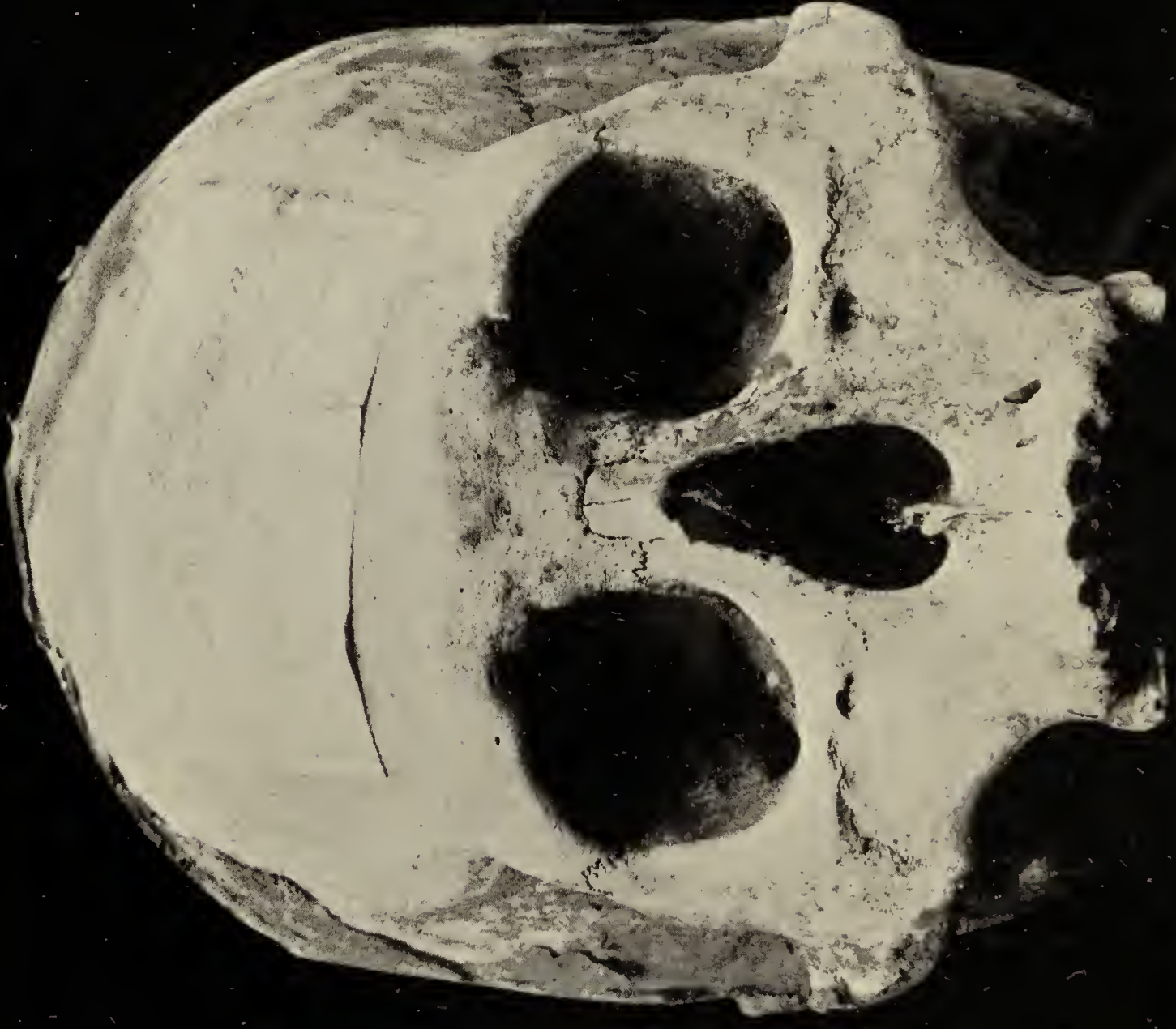




LEFT LATERAL ASPECT OF CRANIUM 17, FROM TARMA







ANTERIOR ASPECT OF CRANIUM 17







explored the bone extensively, and finally located the uppermost radial fissure, and proceeded to develop the principal aperture, completing the operation by grinding down the sharp edges. It seems probable that shortly afterward, perhaps within a few hours, exploration was extended toward the center of the wound so far as to reveal the fracture following the temporo-parietal suture and the transverse fissure across the temporal bone, and that rude cutting and elevating followed in such manner as to produce the irregularly triangular aperture and widen the opening through the bridge separating it from the circular aperture. Remnants of tissue clinging to the bone below the second aperture and still covering the anterior extremity of the curvilinear track indicate that the scalp and upper portion of the ear were not laid back much below the point of impact on or near the suture; and there are indications that at this stage the exploration was diverted and carried downward and backward across the curvilinear fissure and thence along the posterior portion of the suture, and this work seems to have been followed by the scratching or rasping transverse to the lines of fracture. Undoubtedly the last important step in the operation or series of operations was the development of the canoe-shape incision, which cuts across and interrupts or terminates the striæ and incisions produced in the earlier work; this was apparently the first step in a projected operation of greater extent, which was carried no further, presumptively by reason of the death of the patient, which must have been hastened, or even produced, by the clumsy invasion of the meninges in the central part of the incision. It is barely possible, though by no means probable, that the period intervening between the completion of the principal operation and the beginning of the incomplete treatment was of considerable duration and that the two were not connected with the same wound. There is nothing to indicate that any part of the operation was post-mortem, while the abandonment of cutting at an evidently initial stage in an extensive operation seems explicable only on the supposition that it resulted from death under the knife.

In addition to the lesions about the wound, the cranium reveals an old wound in the form of a deep scratch or groove toward the right margin of the frontal bone, nearly parallel with the coronal suture, extending upward 25 mm. from a point 55 mm. above the outer margin of the orbit.

#### CRANIUM 18

(*Plates XXXVII, XXXVIII*)

This skull is excellently preserved, having been taken from a mummified skeleton, though fleshy tissues are absent save for shreds in some of the cavities. It is quite thick and strong, with remarkably developed and rugose attachments. The bones average 6 or 7 mm. in thickness about the three apertures. The teeth are fairly mature, and the union of the sutures is well advanced, indicating middle age.

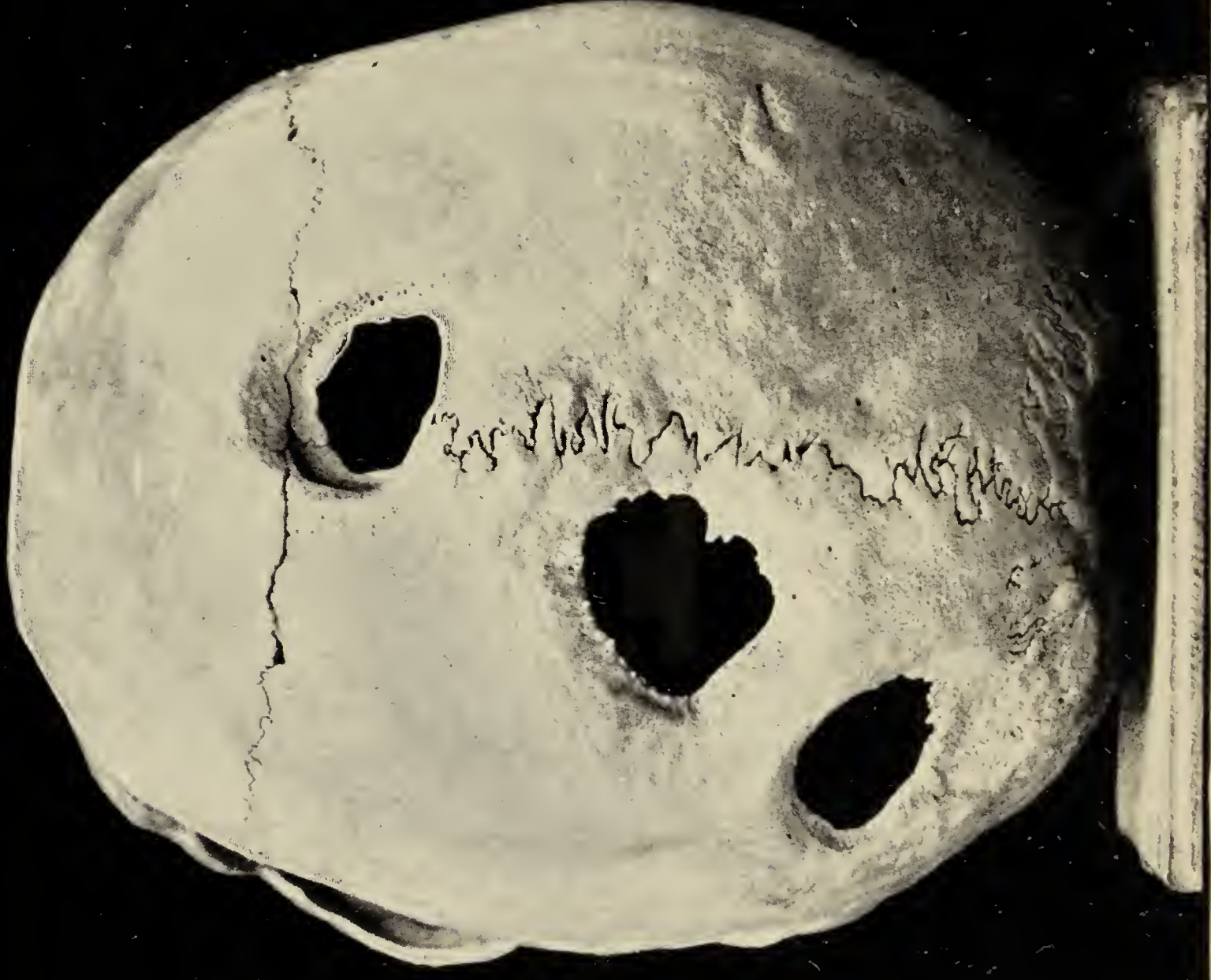


The specimen displays three extensive operations of different dates, without trace of antecedent lesion in any case. The earliest operation was located in the upper portion of the left parietal, adjacent to the sagittal suture, centering about 60 mm. back of the coronal; it resulted in a rudely circular aperture now measuring 29 mm. in longest diameter. Save that the margins are beveled from without, no trace of instrumentation remains; the beveled surface has assumed the texture normal to the exterior of the cranium save for radial lines of reparative growth, increasing in strength toward the edges of the aperture. Many strong spicules and knobs of new bone project from the margin, sometimes so much as 3 or 4 mm. into the opening, while the diploe is completely obliterated. The extent of reparative process indicates that the patient survived the operation for years.

The second operation centered 45 mm. below the first, i. e., near the posterior angle of the left parietal, about 42 mm. from the sagittal suture and 35 mm. from the middle line of the lambdoid. It resulted in a rudely circular aperture now about 25 mm. in mean diameter, in every respect comparable with that of the first operation, save that the reparative modification of the bone is less advanced, especially about the upper margin or toward the antecedent opening. The beveled surface shows ridges of growth, but otherwise approximates the aspect of the normal bone, and appearances indicate that the periosteum was developed over it in quite the normal manner. The diploe is almost wholly obliterated, though it can be detected about the antero-inferior margin of the aperture and also toward the junction of the sagittal and lambdoid sutures. While spicular growth is in general less developed than about the earlier aperture, it is particularly well displayed about the inferior margin, where the spicules are at least 2 or 3 mm. in length and sometimes branch or divide into lateral spicules toward the extremity. There can be no doubt that the individual survived this operation also for some, probably several, years, and it is possible that the two were performed about or (just possibly) at the same date.

The third operation was located in the crown, involving the coronal suture, and traversing the sagittal suture near its anterior extremity. In this case fairly definite traces of instrumentation appear. The clearest marks are of such character as to indicate that they were produced by curvilinear incision effected through the use of a blunt single-point instrument wielded by a vigorous hand; and they are so related in position as to suggest that the operator (being right-handed though somewhat ambidextrous) sat on a low bench or bank, holding the head of the patient (lying supine and facing in the same direction as the operator) somewhat inclined forward between his knees; that he then began a curvilinear incision on the right side, swinging his hand strongly toward the left at the forward end of the stroke as the cut was extended and deepened; and that he gradually, with the use of the left hand or both together, carried the incision around to the left and then toward himself, in such manner as to describe an inverted U or





SUPERIOR ASPECT OF CRANIUM 18, FROM CUZCO (TRIPLE-TREPHINED)







LEFT LATERAL ASPECT OF CRANIUM 18







(more exactly) a horseshoe. In the earlier part of the cutting the knife apparently slipped occasionally, particularly toward the heel extremities, though as the incision deepened care was taken to bring these extremities nearer together. Finally, it would appear that the points of the incision were connected by a transverse cut, slightly curved, made with the right hand, slightly oblique to the axis of the horseshoe, as determined by convenience of movement, whereby the aperture was defined. Throughout the instrument was held obliquely, the obliquity increasing with the depth in such manner that the aperture measures considerably larger on the exterior surface than on the interior, while the profile of the cut surface is slightly concave. The aperture averages about 33 mm. in diameter without, and a little over 20 within. It appears rather probable that an elevator was used before the inner table was penetrated, and that the outer table was removed separately, affording greater freedom in extending the incisions through the inner table. After the aperture was opened, the operation was completed by scraping or rasping down the ragged edges produced in making the incisions and smoothing the entire margin of the aperture, evidently with great care, in such manner as to leave a thin projecting edge of the inner table resting on the intracranial tissues. In this final operation the deep scratches due to the slipping of the instrument toward the point of the horseshoe-shape incision were filed out into broad grooves, but two or three exploratory scratches forward of the opening were allowed to remain. Thus the operation was completed, evidently to the satisfaction of the operator; yet it is doubtful whether the patient, already mature or perhaps somewhat advanced in age, survived. While there are no clear indications of reparative process on the surface of the bone, and no unmistakable growth spicules, the diploe seems to be partially obliterated, and there are a few salients along the thin projected margin of the inner table which suggest secondary growth. On the other hand, there is some discoloration of the skull about the aperture, such as might be produced by localized inflammation, perhaps developing into periostosteitis, suggesting that while the patient survived the immediate operation the sequelæ were fatal. It may be observed that this great aperture, opening almost directly over an important sinus, violates in its location the modern rules of trephining, and could hardly be expected to eventuate otherwise than in the death of the victim.

Of the three operations, two were undoubtedly long ante-mortem, while it is practically certain the third was ante-mortem also. Although the instrumentation is indicated only by the last operation, the similarity in form in the three apertures suggests that all were performed in essentially the same way.

Aside from the operations, there are several indications that the individual led an eventful life; there is a deep contusion near the center of the right parietal (shown in plate XXXVII); there is one of the customary supraorbital grooves or scratches near the right side of the



frontal bone extending 32 mm. upward and backward from a point 34 mm. above the outer margin of the right orbit; and there is an irregular contusion in the frontal, 20 mm. to the left of the median line and 50 mm. above the right orbit.

### CRANIUM 19

(*Plates XXXIX, XL*)

This specimen is the smallest, most fragile, and most delicately molded in the collection; the bone averages  $2\frac{1}{2}$  or 3 mm. in thickness about the single immense aperture. It was found invested with the scalp, tendons, and other tissues, but these were mostly removed, leaving only occasional shreds clinging to the bones, particularly in the cavities. The ligament attachments are better developed than in the average Caucasian skull, particularly about the occiput, though less rugose and deeply striated than in most of the specimens. The small dimensions and several other characters suggest femininity. The age is not easily ascertained: The sutures are ankylosed more completely than in any other specimen of the collection, yet the dentition is quite immature; the anterior molars or "seven-year teeth" are barely erupted, and evidently had not appeared through the gums at the time of death; the "wisdom teeth" are rudimentary, being visible through the bone some distance (4 or 5 mm. on the right and twice as much on the left) below the surface; moreover the mandible is short, allowing absolutely no room for the normal eruption of these teeth. On the whole the cranium has an abnormal aspect in several respects. In addition to the lesions appearing about the locus of operation, there is a pronounced indentation, with some crushing and bruising of the bony surface on the left side of the frontal bone 25 mm. from the median line and 40 mm. above the orbit (shown in plate XXXIX); it partially obliterates one of the usual vertical grooves over the temple. A well developed "Inca bone" replaces the superior angle of the occipital.

The remarkable aperture displayed by this specimen extends from near the center of the right parietal forward and downward through the frontal to a point 18 mm. above the center of the right orbit; it is an elongated oval or ellipse 95 mm. in length and 33 mm. in maximum width measured in the plane of the margins, or about 35 by 105 mm. measured on the curved surface of the skull. Many marks of instrumentation appear, though the earlier have been obscured or obliterated by subsequent scraping or filing. Perhaps the most decisive (which unfortunately is not well brought out in the reproduction) is a rectilinear incision 23 mm. long defining the antero-superior margin of the aperture, of which the terminal portions remain. The anterior terminal, 6 mm. in length, is a groove or cut of the usual V-shape section, though more rounded than usual at the bottom, about 1 mm. in width and 1.5 mm. in greatest depth, shallowing and narrowing toward the







ANTERIOR ASPECT OF CRANIUM 19, FROM HUAROCHIRI







tip, beyond which a narrow scratch extends to the transverse fracture limiting the aperture anteriorly, as best shown in plate XXXIX. The medial portion of this incision forms the margin of the aperture for 10 mm., as shown by both illustrations, especially plate XXXIX, though for most of this distance it was not carried entirely through the inner table, a narrow projection of which remains. The posterior terminal of the incision is somewhat obscured by later scraping, yet it is fairly definite for 5 mm. and similar to the better-preserved anterior extremity. Next in clearness is the curvilinear incision marking the postero-medial margin of the aperture; as shown by its conformation and by longitudinal striae, this was made by a rather blunt-pointed and rough-sided instrument, held vertical and reciprocated with a curvilinear movement. For a length of some 15 mm., measured around the curve, it very nearly penetrated the inner table, leaving a thin projecting edge of bone, as clearly shown in plate XL; thence for 10 mm. forward it shallowed in such manner that, when the elevator was used, most or all of the thickness of the inner table remained after the button was dissevered, and still persists, as shown in both reproductions. Nearly as decisive as these cuts is the rectilinear incision defining the lower side of the aperture from the coronal suture well toward the posterior extremity, a distance of about 35 mm. Although the margin of the outer table has been ground away, one side of this incision still retains its original character, and the bottom of the cut for half its length is shown on the narrow selvage of the inner table left to be broken away when the button was lifted; the incision was of the usual character, as shown by conformation and striae, indicating that it was made with an instrument having a single blunt point and rough sides, operated reciprocally. The entire aperture is circumscribed by scratches and striae produced in smoothing the rough edges of the bone left by the earlier cutting; yet at several points there are deeper grooves or cuts, evidently made in connection with the main incisions, either in a random way or by the slipping of the tool. The most conspicuous of these are outside the better-rounded posterior extremity of the aperture, and several are in such position as to show the effort made by the operator to change the rectilinear incision last described into a curvilinear incision. The marks left by the grinding or rasping of the margin are rough and irregular, such as might readily be produced by rubbing with a coarse sandstone or quartzite; and there is nothing to suggest the use of specialized or metallic instruments.

The location of the operation coincides with that of an extensive compound fracture, most of the traces of which were evidently removed by the operator. One of the lines of fracture extends downward from the anterior extremity of the aperture to the orbit, and may be traced in the wall of the orbit for about 30 mm., and in the interior of the skull may be followed thence into the nasal bones. A branch fracture defines the anterior extremity of the aperture for 5 mm., and thence



extends horizontally for 16 mm., or nearly to the median line, as shown in plate XXXIX, while immediately above it the tables are separated and a scale of the inner table 6 or 7 mm. across is depressed, as shown in plate XL. The antero-inferior margin of the aperture is defined for 15 mm. back of the vertical fissure by an undercut fracture in which the outer table projects 1 to 3 mm. It seems possible, though by no means probable, that some of this fracturing might have been produced in the operation. Below the posterior portion of the aperture a conspicuous crack in the outer table may be traced from the point at which the margin of the aperture coincides with the coronal suture horizontally backward for about 50 mm., as imperfectly shown in plate XL. There are indications also of a fracture coinciding with the coronal suture 30 mm. downward from the lower side of the aperture. Finally, an irregular crack extends from the posterior margin of the aperture backward for 5 or 6 mm., as faintly shown in plate XL. The character and distribution of these fissures suggest an extensive depressed fracture on the right frontal, at a point nearly opposite the indentation on the left, with radial fissures extending in several directions. There are numerous indications that such a wound was explored rather extensively, either before the operation or in connection with it, especially forward and downward toward the orbit. The clearest marks are three or four horizontal scratches midway between the anterior end of the aperture and the outer angle of the orbit (somewhat indistinctly shown in plates XXXIX and XL); and less distinct marks are found over the superciliary ridge and the adjacent surface of the bone nearly to the median line (as obscurely shown in plate XXXIX).

On considering the various features displayed by the specimen, it becomes evident that the fracture antedated the operation, since (1) most of the lines could not be produced by any conceivable impact against the remaining portion of the skull, while (2) some of the fractures (notably that extending backward from the coronal suture) show indications of subsequent physiologic process. It is certain, also, that the operation was completed to the satisfaction of the operator, since no rough edges of bone were left save a few projections of the inner table, which was necessarily difficult of access. Finally it may be considered as established that the individual survived the operation, since in this case, and this only (so far as the Muñiz collection is concerned), a plate of shell was found fitted to the aperture.<sup>1</sup> Judging from the specimen the operation was not long survived, since there is no definite trace of reparative growth, and since traces of periostitis, apparently connected with the wound or with the subsequent operation, may be detected, especially about the coronal suture below the aperture and along the principal fissure extending backward into the parietal.

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<sup>1</sup> Unfortunately this plate, together with all the rest of the collection excepting the nineteen trephined crania, has been destroyed.







RIGHT LATERAL ASPECT OF CRANIUM 19







## METHOD OF OPERATING

The twenty-four or more operations exhibited by the nineteen crania reveal clearly and conclusively the methods pursued by the operators. On reviewing the operations, it appears that the methods were simple, comprising three types of manipulation, which were combined in many instances, probably in all of the completed operations. These types are (1) incising, (2) elevating, and (3) rasping (i. e., grinding, filing, or scraping away the bone by a rough-surfaced or irregular-edged instrument).

The incising was of two fairly distinct but intergrading subtypes, (*a*) rectilinear and (*b*) curvilinear. All of the incisions, so far as clearly revealed, both rectilinear and curvilinear, are essentially similar in form; they are V-shape in section and canoe-shape in plan, broadest and deepest toward the middle, where alone they penetrate the bone, shallowing and narrowing toward the extremities, which frequently project beyond the margin of the aperture. The rectilinear incisions are frequently, and the curvilinear cuts commonly, more or less oblique to the tangent plane passing through the point of cutting.

The rectilinear incisions are well displayed in several specimens, either combined in such manner as to describe quadrilaterals, as in crania 1, 2, 3, and 4, or less regularly disposed, perhaps, about the margins of depressed fractures, as in crania 5, 14, 15, and 19, or else distributed at random as in crania 1 (the outlying incision), 16, and 17, in addition to the many examples of minor cutting or scratching described as exploratory.

The development of rectilinear incision into curvilinear cutting is well illustrated by several examples. In cranium 4, three of the six incisions became curved in consequence of the oblique attitude in which the instrument was held by the operator in its passage across the spherical surface of the skull, and a fourth incision was strongly curved toward one of its extremities, evidently because of deflection of the instrument by the superciliary ridge; and one of the random cuts in cranium 16 is curved at both extremities, by reason of rugosities of the surface of the bone, in such manner as to assume a somewhat curvilinear form. In other cases the incisions were evidently curved by studied effort, as most clearly shown in cranium 6. In this case it is clear that the operator began with a rather short vertical and rectilinear incision, which was in one direction developed into a curve, partly by lateral deflection of the instrument at one end of the reciprocal stroke, partly by holding it more obliquely as the cutting proceeded. Of like significance are the partly rectilinear partly curvilinear incisions displayed in crania 7 (the later operation), 18, and 19; while in still other cases, in which the marks of instrumentation have been obscured by subsequent rasping or obliterated by reparative growth, the form of the aperture suggests a similar combination of rectilinear

incision developed into curvilinear cutting, as in crania 9, 11, 12, 13, and 18 (the two earlier operations). In only one case (cranium 8) does the curvilinear cutting closely approach circularity, and even in this case one side is a tangent exceeding half the diameter of the aperture, while there are indications that the final rasping was designed to remove projecting termini and scratches produced in the gradual diversion of an originally rectilinear cut.

Accordingly the first type of manipulation may be traced from simple rectilinear incisions, either random or arranged quadrilaterally, through various combinations of straight and curved cuts up to approximate circularity; in which form, of course, the extent of the lesion and the vital force required for recovery and reparation are reduced to a minimum. It is not known that this sequence has either geographic or chronologic significance; the lowest types (crania 1 and 2) are both from Huarochiri, as is also the highest (cranium 8), and there is nothing save the differentiation in method to suggest difference in period. It is on the whole probable that the differences in refinement in manipulation merely represent varying degrees of skill on the part of essentially contemporary operators.

The elevation of the button outlined and partially dissevered by the incisions is indicated clearly in one case, and with strong probability in at least six others, and is suggested in several additional cases. In cranium 4 one of the margins of the irregular aperture is crushed, splintered, and undercut in such manner as to record unmistakably the application of the elevator lever-fashion over this part as a fulcrum; while the broken edges of the inner table and the margins of the aperture generally were evidently produced by the forcible elevation and breaking outward of the button. In cranium 15 the splinters and fragments of the fractured bone were evidently removed, either entire or in pieces, so forcibly as to leave jagged edges, especially of the inner table, and carry one side of the aperture beyond the incision designed to define it. In cranium 7 (the later operation) the thick button was apparently forced outward by strong pressure exercised by means of an elevator inserted in the incision and used as a lever fulcrumed on the outer wall of bone, whereby one of the margins of the aperture was carried beyond the limiting incision in the inner table; the thin edge of the inner part of the bone about the latest aperture in cranium 18 tells a similar story, and suggests that the tables were separated before the button was finally removed; and equally decisive are the jagged edges of the inner table part of the way around the immense aperture in cranium 19. In crania 1, 2, 5, 12, and 17 also there are jagged margins, especially of the inner table, which could have been produced only by the forcible removal of the button through outward pressure applied by means of an elevator. As with incising, so also with elevating, there are several cases in which no evidence of the process remains; but (excluding the examples of rasping) these are cases in which the marks of instrumen-



tation have been obliterated by subsequent smoothing of edges or physiologic action. There is no case in which traces of incising persist that does not afford suggestion or more decisive proof of the employment of an elevatory process.

The process of rasping is distinctly exemplified by several of the specimens. Perhaps the clearest evidence is that afforded by cranium 16, which displays a complete operation without trace of incision or elevation, apparently produced wholly by rasping, scraping, or grinding. It is true that the outlying marks are for the most part indistinct, but this may be ascribed to increasing delicacy of manipulation as the process was brought to an end—a delicacy attested by the paper-like thinness of the remaining margin of the inner table; and a sufficient number of striae are preserved to at least suggest the extension of the process over the entire area of this particular operation. In addition, unmistakable marks of rasping or scraping follow the ghastly fissure for at least 50 mm., where they merge into exploratory scratches. In cranium 10 the conformation of the aperture and its margins and the adjacent portions of the skull suggest that the entire operation was performed by rasping or scraping, precisely as in cranium 16, without attendant incision, although in this case all direct traces of instrumentation have been obliterated by reparative process. In cranium 12 (the later operation) the process of rasping or scraping was carried over a considerable area, and one of the three apertures appears to have been produced wholly by this process; and in crania 17 (the upper opening) and 19 the apertures are circumscribed by approximately concentric striae, showing that the process was employed for working down rough edges. So, too, in crania 7 (the later operation) and 18 (the latest operation) the striae are so disposed as clearly to indicate that rasping was employed to smooth the bony edges and obliterate the rough projecting kerfs due to irregularity in incision, and the same relation is indicated with almost equal clearness by the striae about the nearly circular aperture in cranium 8.

Several of the specimens are without traces of rasping or scraping. These fall into two groups, in one of which the operation was evidently incomplete, while in the second the more delicate (at least) of the marks of instrumentation have been obliterated by physiologic process. To the first group belong crania 1, 2, 3, 4, 5, 6, 14, and 15, all of which afford independent indications that the subjects died under the knife, either in consequence of the original lesion or from the effects of the operation. The second group comprises crania 7 (the earlier operation), 13 (both operations), and 18 (the two earlier operations), with more doubtfully crania 9 and 11, in which there is collateral evidence of long survival and extensive reparative process. In every case in which the operation was presumptively complete, and in which traces of instrumentation have not presumptively been obliterated by physiologic action, as well as in several others, rasping is exemplified.

Summarily, it appears that the three processes of incising, elevating, and rasping were commonly and perhaps invariably employed in definite sequence in producing a complete operation; in general, the treatment began with exploratory scraping or cutting and proceeded to definite incision; at a stage determined by the conditions the operator had recourse to elevation and thereby forcibly and often violently dis-severed the button; as the operation approached completion the edges of the bone were reduced by rasping or scraping. There are only one or two cases in which there is not either direct or strong presumptive evidence of the process of incising; in most of the cases also there is either direct or strongly presumptive evidence of elevating, and in every suitably conditioned case there is conclusive evidence of rasping.

#### INSTRUMENTS

More than half of the specimens indicate with considerable clearness the character of the incising instrument and somewhat less clearly the nature of the rasping instrument, while there is little indication concerning the instrument used as an elevator.

The incising instrument evidently possessed a single rather blunt point, without shoulders or other device to limit the depth of cutting; the bluntness is indicated by the width of the bottom of the kerf, which is always rounded or concave for a width ranging from 0.5 mm. to 1.5 mm.; the fact that the point was single is indicated by the frequency with which it slipped toward the termini of the incisions and by the character of the scratches thereby produced, while the absence of shoulder is indicated by the variability in depth of the incisions and by the freedom of the margins of the incisions from striation or other marks of friction in every case in which the details of the operation are clear. In addition to bluntness at the tip, the instrument thickened rapidly in the body, as attested by the somewhat flaring V-shape of the incisions, which are frequently as wide, and never less than half as wide, as deep. The form in plan, section, and longitudinal profile of every well-preserved incision indicates that the single point was operated by a reciprocal motion, so as to form a single-tooth saw, sufficient downward pressure being exercised to cause it to "bite" the bone, and thus produce a kerf having a width determined by the thickness of the instrument, and a length and longitudinal profile determined by the length of stroke and the center of partial revolution of the instrument in the hand of the holder; for in most cases in which the kerf is well preserved the longitudinal profile is more or less concave, indicating that the tip of the instrument moved through a longer radius than its head. Also the well-preserved incisions indicate that the instrument was not only blunt-tipped but rough-sided, for the sides of the kerfs are striated longitudinally, though somewhat irregularly.

There is nothing to suggest in any case that the point of the instrument was round or square, and decisive indications in many cases that



the rather blunt tip expanded longitudinally in the form of a blade considerably broader than thick. The rectilinear incisions give little indication of the relative width and thickness of the tools, but the curvilinear kerfs suggest that the longitudinal width must have been two or three or more times the transverse dimension—i. e., that the tool must have been a blade measuring, at a distance of say 8 mm. from the tip, about 3 or 4 mm. from side to side, and somewhere between 5 and 10 mm. from edge to edge.

It is, of course, impossible to estimate, with any approach to accuracy, the length of the blade, which might or might not have been hafted, but it is practicable to estimate roughly the total length of the instrument, including the haft, if hafted, from the curvature in bottom profile of the incisions, assuming the tool to have been held in convenient fashion in one hand; and such an estimate, based on the well-preserved incisions in crania 1; 2, 14, 15, 16, and 17, ranges from about 50 or 75 to some 150 or 200 mm.; i. e., it seems probable that the instrument was long enough to be handled conveniently in one hand, with the occasional assistance of the other.

Putting the various dimensions together, they are found to define a blade corresponding with an ordinary stone knife or spearhead, or with an arrowpoint attached to a short haft, while the dimensions are inconsistent with those possessed by any known cutting instrument of metal. Considering next the longitudinal striæ in the sides of the kerfs, it appears that they would naturally and necessarily be produced by the reciprocal operation of a knife or spearhead chipped from stone of coarse texture or of such structure as to give a splintery fracture, and that these features would not be produced by any known single-point tool of metal, polished stone, tooth, or shell. Accordingly, the detailed features displayed by the collection afford practically conclusive evidence that the incising instrument was a stone blade of common form and character. There is absolutely no suggestion in any of the specimens that the kerfs were produced by any other kind of tool, either of other material than stone or of other form than a blunt single-tip blade.

Several of the crania indicate that the rasping was effected by an irregularly rough surface, since the striæ are unequal in depth and variable in contour and length. In only a single instance (cranium 8) are the striæ sufficiently uniform even to suggest the use of a regularly formed rasp or file of metal or other tough material, and even in this case careful examination shows that the uniformity is almost certainly due to exceptional shortness of stroke in beveling the narrow marginal zone (1 to 9 mm. in width) of the outer table of the skull. In most cases the striæ are precisely such as those traversing longitudinally the sides of the cuts, and this similarity suggests that they were effected simply by rubbing with the side of a blade chipped from stone of coarse texture or splintery fracture.



In some cases the size of the instrument used for rasping is roughly indicated. The grinding out of the kerf terminals in crania 7 (the later operation) and 18 (the latest operation) produced surfaces curved in two dimensions, of such degree of curvature as to indicate that the instrument must have been about the size of the blade inferred from the incisions; moreover, in cranium 16 the striæ traversing the fracture terminate anteriorly in a series of scratches precisely such as accompany the kerf terminals, suggesting that in this instance, at least, the striæ were produced by the distal portion of a blunt-point instrument corresponding generally to the incising tool.

Accordingly, there is a fairly conclusive body of evidence that the rasping was effected by means of common stone implements, either identical with or closely similar to those used in cutting, and there are no marks which might not be produced by such an instrument, nor is there the least indication that instruments of metal, tooth, or shell were employed, though it is possible that some of the work (e. g., in cranium 10, in which the traces of instrumentation are practically obliterated) might have been performed with other materials than stone, the scraping of the South Sea islanders being suggested.

In the single case in which the bony fulcrum of the elevator is distinctively preserved (cranium 4), the marks indicate merely that the instrument was rough or irregular, rather than smoothly rounded, suggesting that the elevator was nothing more than the stone blade used in making the incision. In several cases, however, there are indications that considerable force was exerted in raising the buttock, perhaps requiring a tougher material than stone, which suggests that special instruments of tooth, antler, or hard wood might have been employed for this purpose.

It may be noted in passing that the Squier cranium corresponds in indications of instrumentation with crania 1 and 3 of the Muñiz collection, while several of the Cuzco crania indicate the employment of dissimilar methods and distinct instruments; but in the absence of decisive facts, such as can be obtained only by critical examination of the specimens themselves, these examples of Peruvian trephining may be passed over without detailed consideration.

Summarily it appears that the instruments used in performing the operations exemplified in the Muñiz collection were chiefly or exclusively stone implements of the character found among nearly all primitive peoples, including the ancient Peruvians. There is nothing to indicate that the instruments were in any way specialized; there is absolutely no indication of the employment of trephines, saws, or other multiple-point instruments, and only negative suggestions concerning the use of metal.

## PROCEDURE OF THE OPERATORS

Some idea as to the technique of Peruvian trephining may be gained from a study of the procedure of the operators, as indicated by the character and sequence of steps in the better revealed operations. There are many indications that the operators were (1) inexpert in manipulation, (2) ignorant of physiology, (3) skillless in diagnosis and treatment, and (4) regardless of the gravity of the operations performed.

As already noted, there was a sequence in refinement of the bone cutting, running from the extravagant quadrangular button with eight projecting kerfs exemplified by cranium 1, and the still more barbarous slashing shown in cranium 5, to the relatively refined circular incision of cranium 8. Yet there is nothing to indicate that the sequence means anything more than a simple transition from the more clumsy to the less. There is scarcely a specimen, not modified by reparative growth, that does not display more or less extended kerf terminals and extensive scratches produced by the slipping of the tool; and the apertures display an irregularity of form attesting unfamiliarity either with geometric proportion in general or with the production of geometric figures by means of the facilities and under the conditions represented by the work. Most of the operations were evidently performed in random fashion without definite plan, by rule of thumb or by no rule at all. There was apparently no uniformity in the orientation of the quadrangular operations save that of convenience in operating, and in several cases (e. g., in the later operation in cranium 7, in cranium 8, and in the latest operation in cranium 18) the outline of the cutting was manifestly determined by the attitude in which the subject was placed. In some of the more refined operations the incising blade was apparently held in such manner as to produce a tapering button and beveled margin, yet most of the rectilinear and some of the curvilinear kerfs indicate that the tool was variously inclined, either through pure clumsiness and inattention, as in the outlying incision in cranium 1, in which (apparently by reason in part of interference with the integument) the tool was inclined at such an angle to the tangent as to require the cutting of bone to nearly twice the normal thickness of the skull, or by effort to keep the hand (and tool) out of the way of vision, as in cranium 8. So, too, when the bony surface was irregular or protuberant the tool was permitted to diverge, regardless of the original direction, as in crania 4 and 16. In short, there is nothing to indicate definite plan or deft execution in any of the operations.

The extravagant incision and violent elevation characterizing many of the operations necessarily rendered the artificial lesions much more extensive and dangerous than necessary, and the frequency with which this needless danger was incurred indicates that the operators had little if any notion of the physiologic processes involved in resistance, recovery, and reparation. In several cases, too, the cutting was carelessly carried entirely through the bony tables so extensively as to



indicate that the tool penetrated the intracranial tissues in such manner that the operation probably became the immediate cause of the death of the victim, as in crania 1, 4, 5, and 17, and perhaps 2, 3, 6, 12 (the later operation), and 15; this highly indefensible procedure apparently growing out of ignorance concerning the delicacy of brain and meninges. Again, the apertures seem to be located altogether at random with respect to the structures affected; no fewer than nine of the twenty-four operations involve sutures, and at least two (crania 13 and 18) were, apparently needlessly, so located as to traverse the sagittal suture about its union with the coronal, thereby endangering especially delicate and conspicuous structures. Several of the operations were, indeed, evidently located by wounds, and these cases might be considered so desperate as to override ordinary prudence; yet a sufficient number are so manifestly ill placed as to indicate that the operator knew not whereof he wrought.

While the inference seems unavoidable that some of the operations were intentionally located by traumatic lesions—indeed, the evidence of cranium 14 alone would appear conclusive on this point, even if it were not corroborated by that of 15, 16, 17, and 19—yet there are a number of examples of aberrant location and erratic exploration. In cranium 1 no trace of antecedent lesion can be found about the locus of operation, though there was an evidently fresh wound, of a severity indicated by fracturing of the outer table, in a remote part of the skull; yet there is no indication of treatment about the wound, while exploratory marks are found 30, 40, and even 50 mm. away from the center of the operation in the four cardinal directions, and the great outlying incision would seem to have been exploratory or experimental. So also the score of widely distributed incisions, with exploratory scratches extending 25 mm. farther, displayed by cranium 5, tell of thoughtless hacking, with no indication of diagnosis or intelligent adaptation of means to ends. The fact that curative treatment was essayed at all in connection with the fearful wound displayed by cranium 16 would appear to indicate utter incompetence in diagnosis; and the fact that the chief treatment was located far from the center of the lesion, and that some of the more ambitious slashes were entirely beyond the region affected by the extensive fracture, strongly indicates absence of diagnosis in the ordinary sense, and demonstrates that the treatment was altogether inapplicable. In cranium 17, too, the operator went far afield in his earlier efforts, and evidently completed an operation that had very little to do with the essential features of a wound which must have displayed conspicuous symptoms, and it is evident that he only approached the real locus of the lesion subsequently, and then in an indefinite and blundering fashion which apparently resulted in the death of the long-suffering subject. These cases of obvious blundering might be doubled or tripled in the collection; they are only typical. Thus there are several examples of glaringly



defective diagnosis and ill-directed treatment, while, with the possible exception of crania 14 and 15 (in which the indications may easily be illusive), no examples are found to prove or even to suggest diagnostic skill—there is much evidence against and no evidence in favor of the competence of the primitive practitioner.

A striking feature of the collection is the magnitude and boldness of the operations displayed by the crania. In one instance (cranium 2) the operator evidently sought to minimize the area affected by his treatment; in another instance (cranium 8) the operation suggests studied economy of vital force; in two cases (crania 14 and 15) the treatment was coextensive with the traumatism; while in three cases (crania 16, 17, and 19) the treatment was more restricted than the antecedent lesion. In nearly all the other cases the treatment seems to have been unnecessarily extravagant, while in several instances (already noted) the cutting was so reckless as almost necessarily to invade the cerebral tissues and occasion the death of the subjects. Even in the three cases in which the antecedent lesion was more extensive than the treatment, the recklessness of procedure is indicated by aberrant location, as well as by the fact that the operation was undertaken in connection with almost necessarily fatal wounds, as must have been clearly indicated by unmistakable conditions and symptoms. So, too, complete disregard of suffering on the part of the patients is attested by the rude and wide-reaching scratches and the violent outwrenching of the buttons, while the extensive wounding of the periosteum was barbarous, largely needless, and wholly irrational. The only definite suggestion of post-mortem operation found in the collection arises in the reckless and inhuman slashing of integument, bone, and brain by evidently needless operations.

In short, Peruvian trephining, as exemplified in the Muñiz collection, can only be regarded as crude in plan and bungling in procedure; and study of the procedure only occasions surprise that the results were not worse, and awakens admiration for the powerful vitality which enabled so large a proportion of the victims to survive.

#### THE MOTIVE FOR OPERATING

##### GENERAL INDICATIONS OF MOTIVE

The characteristics of the crania throw some light on the question as to the motives actuating the primitive practitioners of Peru. Sixteen and probably 17 or 18 of the 19 specimens are almost certainly masculine, and represent early and vigorous maturity; all of the well-preserved examples are remarkable for the thickness and strength of the bone and the rugosity of the ligament attachments, while the ill-preserved specimens apparently differ only by reason of the weathering and erosion to which they have been subjected. The first specimen of doubtful gender is the fragmentary cranium 6, which is questionable

only by reason of the fact that the single parietal bone does not admit of satisfactory comparison with the entire specimens; the second is the small and delicately molded cranium 12, which may be feminine; the third is the small specimen of somewhat abnormal appearance (number 19) with mature sutures and immature dentition, which may be feminine also, though it seems quite as probable that it represents an ill-developed male. Collectively the crania appear to represent vigorous and healthy young men, presumptively soldiery; there is every indication of fine physical development, not only in strength of tissue, but in soundness of constitution as indicated by the frequent survival of desperate wounds and even more desperate treatment; yet there is nothing in the crania themselves or in the evidence of the instruments and operations to indicate noteworthy intellectual development.

The individual and collective characteristics indicated by osseous and muscular development are no less clearly shown in the minor traumatic lesions displayed by most of the crania. Cranium 1 displays a late ante-mortem contusion with slight fracture of the frontal bone and, in addition, two long healed grooves over the left temple; cranium 2 reveals a similar groove over the right temple, an extensive indentation of the frontal bone, and two suggestive gashes in the back of the head (perhaps pathologic); cranium 4 exhibits an indentation some 25 mm. in diameter, evidently traumatic, near the center of the right half of the frontal bone; cranium 5 displays traces (partially obliterated by the subsequent hacking of the operation) of the customary vertical groove over the left temple; cranium 7 reveals two such grooves on the left, and two others of exceptional length on the right; cranium 10 has two long parallel grooves, somewhat fresher in aspect than usual, over the right temple, and two others, forming a narrow V over the left temple, with a shorter one placed exceptionally low on either side, or in all six cuts symmetrically grouped; cranium 11 is distorted and greatly flattened in the antero-posterior dimension, and displays the characteristic groove on the right; cranium 12 exhibits an extensive contusion at the summit of the frontal bone, two less extensive indentations near the center of the left half of the same bone, an abnormal scale at the anterior angle of the right parietal, and a long healed groove on the left side of the frontal; cranium 15 displays a completely healed contusion in the center of the frontal, a short gash above the right orbit, and one of the usual grooves above either temple, with a shorter parallel groove on the left; there is in addition a partially healed fracture and indentation of the outer table near the left upper margin of the frontal; cranium 16 displays an immense scar, perhaps of pathologic rather than traumatic origin, a little to the right of the center in the upper part of the frontal, and there are the usual ante-mortem grooves above the temples, that on the left being particularly long and deep; cranium 17 reveals the usual groove on the right, with an inconspicuous corresponding mark on the left; cranium 18 is indented by a deep groove of the usual character over the right temple, and displays a considerable



though not very deep scar midway between the left orbit and the crown, and a deeper scar near the center of the right parietal; while cranium 19 shows an inconspicuous mark of the usual character over the left temple, and in addition a considerable contusion by which the outer table is somewhat crushed and both tables depressed. These unmistakable records of traumatic history are additional to the operations, single and multiple, and to the more or less extensive wounds with which several of them are connected. There are accordingly four classes of traumatic injuries represented, viz, (1) those produced by the trephining, (2) the antecedent fractures displayed by five of the crania, (3) the curious grooves over the temples exhibited by most of the specimens, and (4) the miscellaneous indentations and bone scars displayed by fully half the crania. Excluding the first three classes, the 19 specimens display no fewer than 14 traumatic lesions resulting from injuries to the head, which were more or less serious, yet always of such severity as to leave clear traces in the bony structure; and nearly all of these were anterior. The five wounds of the second class were of such severity as almost necessarily to be mortal. This remarkable record of accident indicates that the individuals lived eventful albeit short lives, and were inured to blood and pain and accustomed to facing danger. The peculiar scoring above the temples (of which 23 examples are displayed by the 17 frontal bones) is much too regular to be ascribed to fortuitous wounding; without examination of a larger number of crania and careful consideration of their associations, these marks may not safely be interpreted; yet it may be suggested (the suggestion arising in analogies with other American aborigines) that they are records of ceremonial observances in which wounds were inflicted on young men chosen for initiation into militant or other orders. The scars indicate lesions no more serious and probably less painful than those of the Mandan and Hidatsa tribes of North America, while some of the Pueblo Indians, who are still more closely connected in culture with the South American peoples, have initiatory ceremonies involving symbolic wounding of the head, which can only be regarded as the vestige of an archaic custom of actual wounding in the initiation. So, too, the "scarred skulls from Florida," recently brought to light by Cushing, are marked by regular ridges of papuloid bony growth, which seem to have resulted from the cicatrization of the scalp; the inference being that the marks were made in producing a permanent symbolic crest of hair, supplemented by feathers, etc., to distinguish the warriors.<sup>1</sup>

Some indications of motive may be found in the antiquity of the collection, as evidenced by the methods of operating. In every case in which the marks of instrumentation are preserved they point clearly and unmistakably to the use of primitive tools, mainly or wholly of stone; there is no suggestion of the slightest value that metal was used in any part of the treatment; and while there is a certain similarity

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<sup>1</sup> American Anthropologist, volume x, 1897, pp. 17-18.



running through all trephining operations, there is not the slightest indication that these primitive operations were influenced by the refined methods of civilization, and strong indications that some of them—notably the operations by rectangular cutting—were autochthonous. Accordingly the inherent evidence of the collection appears to prove that all of these cases of trephining antedated the advent of white men, and were thus essentially prehistoric.<sup>1</sup>

Another indication of motive may be derived from the period of the operation with respect to the life of the individual treated. Out of the 24 cases represented by distinct operations, 8—recorded by crania 7 (two operations), 10, 12 (the earliest operation), 13 (two operations), and 18 (the two earlier operations)—survived long enough to permit more or less extensive reparative changes and considerable bony growth, while 6 other cases—recorded in crania 8, 9, 11, 12, 18 (the third operation), and 19—apparently survived for days or months, and in some cases perhaps for years. Excluding the case exemplified by cranium 19 (in which the antecedent lesion was almost necessarily fatal) this gives a ratio of 13 survivals out of 24 operations, or a percentage quite as high as that of modern practice. In one case (that exemplified in cranium 16) it is clear that the patient died under the operation, and that the treatment was abandoned without closing the integument; in at least 2 cases (those of crania 1 and 5) there is practically conclusive evidence in the condition of the bone that the victim died in or very soon after the operation; while in 3 other cases (recorded in crania 14, 15, and 17) the relation between the cutting and evidently antecedent wounds indicates that the patients died in the hands of the operators. Accordingly, in 6 (7 if cranium 19 be reckoned) out of 23 cases, either the operations or the immediately antecedent lesions were undoubtedly fatal. In one case (represented by cranium 2) death seems to have supervened on an operation connected with the diseased condition of the bone; and there remain 3 cases (those of crania 3, 4, and 6) in which the state of preservation is hardly such as to indicate the relation of the operations to the life of the individual with certitude, though in two of these there is forcible suggestion of death under the knife. On the whole, it is certain that over half of the operations were long ante-mortem, and that most of the remainder were ante-mortem at least in their inception, and there is not the slightest indication, except in the otherwise explicable rudeness of the treatment, that any of the operations were post-mortem.

Still another indication concerning motive appears in the form and character of the buttons or bony fragments removed by the operators.

<sup>1</sup>It may be noted that the above inference from the trephined crania is in accord with voluminous and indubitable evidence obtained by Dr Muñiz that all of the arts of the people represented by the crania were archaic, and of prehistoric type exclusively—indeed, according to Dr Muñiz, the associations clearly indicate not only a pre-Spanish but a pre-Incan age for the ancient trephiners. The only notable suggestion of less antiquity is that of the designation given by Squier to the skull obtained by him from Señora Zentino, and said to have been taken some time before from an "Inca cemetery in the valley of Yncay" ("Peru—Incidents of Travel and Exploration in the Land of the Incas," 1877, page 456); and it is clear that in this case the evidence of Incan age is far from complete.

Cranium 4 displays cutting in such manner as to describe four irregularly rectangular bits of bone, while the work on cranium 5 yielded a still larger number of still more irregular fragments. The operation exemplified by cranium 8 may, indeed, have yielded a circular button, but considerable additional bone was removed in minute shreds by subsequent rasping. If the operation in cranium 10 was performed wholly by scraping, as appearances indicate, then all of the dislodged bone came away in shreds or filings; in the later operation or operations on cranium 12 most of the bony matter seems to have been removed by scraping; in cranium 14 bony splinters only were removed, and in cranium 15 such splinters in connection with a probably broken bony tongue of irregular form. So, too, in all the other cases there are unmistakable indications that the purpose of the operator was to produce an aperture, and not to obtain bone fragments of any particular form or size; and there is not the slightest indication in any of the specimens that the cutting was designed to yield rondelles.<sup>1</sup>

#### SPECIAL INDICATIONS OF MOTIVE

Strong yet somewhat illusive light is thrown on the motives actuating the prehistoric practitioners of Peru by the relations between trephining and traumatic lesions. In 6 cases (exemplified by crania 6, 14-17, and 19) the operations were evidently located by grave wounds. The 13 remaining crania display 18 operations having no traceable connection with lesions, while, as already enumerated, no fewer than 14 scars of more or less serious wounds (some of considerable gravity) are displayed, none of which were treated by trephining. The 23 examples of manifestly intentional wounding of such severity as to leave bone scars over the temples may be neglected. Accordingly it appears that, while there are a few cases of indubitable connection between operation and antecedent lesion, this relation is subordinate—in most cases the cranial lesions did not lead to trephining, while in the great majority of cases the trephining was apparently not connected with traumatic lesion. In one case (cranium 2) there is a strong suggestion that the operation was connected with pathologic lesion; yet this case does not materially affect the relations between lesion and trephining. The relations may perhaps best be summarized by the statements (1) that most of the operations were independent of cranial wounds so far as can be ascertained; (2) that most of the cranial lesions were not followed by trephining; and (3) that only wounds of great severity were followed by cranial treatment.

On considering specially the six crania (6, 14-17, and 19) displaying operations located by immediately antecedent wounds, they appear to

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<sup>1</sup>This inference from the crania is in accord with the general results of Peruvian collecting by Dr Muñiz and others. Among the many thousand specimens representing the apparel, ornaments, and other personal appurtenances found by Dr Muñiz in connection with more than a thousand skeletons, and despite constant search, not a single rondelle or other object made from human cranial bone was found; and no record of the discovery of such objects by any of the numerous students of Peruvian archeology is known.



fall into three categories. In the first category, represented by crania 6, 14, and 15, the operations were located by depressed fractures of considerable gravity, and the procedure, albeit clumsy, was of such character as to tend to afford relief—i. e., the wounds were such as modern practitioners would treat by cranial cutting, including the removal of bony splinters, the excision of rough edges, and the elevation of the depressed bone, in a manner corresponding fairly with the primitive procedure. Accordingly, if these cases stood by themselves, they would appear to indicate rational therapeutic surgery; and the indication of the operation coinciding with pathologic lesion (cranium 2) is similar. The second category is represented by cranium 19, in which the wound was apparently a depressed fracture, with extensive stellate fissuring—i. e., a wound in which trephining would be indicated to modern practitioners, unless the symptoms permitted diagnosis of the great extension of one of these fissures through the orbital and nasal bones. Accordingly, this example also suggests rational therapeutic motive, and the suggestion is greatly strengthened by the use of a plate. In the third category, represented by crania 16 and 17, on the other hand, the treatment was not only barbarous and clumsy, but ill directed. In the first example the wound was of such character as to contraindicate trephining, while in the second it was of such nature as to require a treatment quite different from that adopted. As already noted, this and several other cases demonstrate ignorance of physiology and etiology on the part of the operators. They might, perhaps, be regarded as representing the efforts of specially bungling practitioners, though there is nothing save the treatment in the three or four foregoing cases to suggest greater skill on the part of any of the practitioners; and accordingly these examples can hardly be considered to represent a rational therapeutic surgery. On the whole, this group of crania, taken by themselves, appear at first sight, albeit somewhat doubtfully, to represent definite therapeutic treatment; yet it is to be observed that their testimony is indicative or merely suggestive rather than conclusive.

On considering the outcome of the treatment exemplified in the six cases, a significant relation appears—three of the victims died under the knife early in the operation, two more died before the aimless hacking and scraping was completed, and the sixth died after the operation was completed but before the beginning of reparative process in the bone. Thus none of the subjects of the suggested therapeutic treatment survived. It is true that in three of the cases the wounds were almost necessarily fatal, and that in the others they were so serious as probably to result fatally without prompt and judicious treatment, yet the fact remains that the collection shows absolutely no basis for the encouragement of trephining as a therapeutic treatment for traumatic lesions.

Accordingly, on full consideration of all of the facts and relations displayed by the group of crania in which the operations were located



by antecedent wounds, the question arises whether—superficial indications to the contrary notwithstanding—there is any definite indication that the trephining was therapeutic; on the one hand, there is (1) the association in place and the sequence in time of lesion and cutting, and (2) the fact that in two or three cases trephining was adapted to the relief of the wound; on the other hand, there is (1) the aberrant location of the cutting and the reckless exploration in two cases; (2) the ignorance of physiology and etiology demonstrated by these and other specimens, and (3) the invariable failure of the operation, regarded as a curative treatment. On the whole, it would appear, even when attention is confined to the inherent evidence of this most suggestive portion of the collection, exceedingly doubtful whether the cranial cutting can justly be considered therapeutic.

Neglecting cranium 2 (in which there are doubtful indications of location of the operation by pathologic lesions), there remain 11 crania, displaying 16 operations, none of which can be traced to antecedent lesions of any sort. In these cases, therefore, there is no suggestion of motive. Accordingly, it seems needful and unobjectionable to seek explanation of these operations in the records concerning other peoples of corresponding cultural development. For immediate explanation, it will suffice to consider the primitive operation performed among the South Sea islanders by scraping with stone or shell and covering with plates of cocoanut shell. Among them the operation is not designed to relieve traumatic lesions, so far as the records show, but to relieve various neural and cerebral disorders, such as vertigo and even simple headache; and the operation is performed by the shaman. Now, while the records concerning the South Sea islanders are adequate so far as procedure and results are concerned, there are clear indications that the recorders did not so fully enter into the ideas of the operators as to understand the motives by which they were actuated; but the motives can easily be inferred from those actuating the shamans among other peoples of the same culture-grade. Among the Indians of North America and South America, among the Australian aborigines, among several native African tribes, and among different Eurasian peoples after the dawn of history, the shamanistic diagnosis and motive were closely similar. The medicine-man ascribed the disorder to an evil "mystery," often an imaginary worm, sometimes an inanimate foreign body, lodged in the flesh, bone, marrow, brain, or intestines of the sufferer, and the treatment consisted in the exorcism or extraction of the foreign organism or substance by incantation, sometimes accompanied by local manipulation or other treatment; and among those tribes in which this notion of disease and its treatment culminated, the imaginary maleficent organism or substance was commonly symbolized by an actual worm or grub, or a pebble, or a bit of wood or other substance, which the shaman dexterously manipulated in such manner as to convey to the lay observers the impression that it was taken from the body of the sufferer. As

culture advanced, the materialization or incarnation of the evil "mystery" declined, yet the primitive theory of disease persisted long, and indeed crops out today in the lower strata of civilization in every country on the globe; and medicine-men and medicine-women, wearing the mantles of the shamans of old, treat disease by incantation and exorcism, perhaps accompanied by simple medication or manipulation, which not infrequently chances to be beneficial. Thus, although the records of trephining among the South Sea islanders are in one respect incomplete, there can be little doubt as to the motive underlying the operation. Interpreted in the light of invariable ideation among primitive peoples, the motive must be considered thaumaturgic, and the actuating idea the design of liberating some maleficent "mystery" by a ceremonial incantation grown into local treatment of unusual severity; and in view of the unanimity of motive among all primitive peoples, so far as known, it seems not only just and safe but necessary to ascribe to the ancient practitioners of Peru the motives of other American Indians as well as the methods of the South Sea islanders. Thus the 16 apparently erratic and aimless operations displayed in these 11 crania find a rational and adequate explanation; the treatment may have been for vertigo, headache, or other disease; for coma, produced by shocks or blows of such character as to leave no marks, or for trifling wounds; but it is safe to consider the trephining thaumaturgic and (albeit perchance beneficial) wholly independent of physiologic knowledge and etiologic skill.

On considering the relation of this group of operations to individual history, it appears that at least 6 out of 16 were so far successful that the subjects survived for years, as attested by growth of bone, and that at least 4 and perhaps 5 more survived for shorter periods, giving a ratio of success quite as high as that attending modern practice; so that, whatever the motive in detail, there was adequate prestige for the practitioners and adequate encouragement for continuing the practice.

Recurring now to the 5 or 6 crania displaying antecedent lesions associated with the operations, and considering the cases in the light of the almost inevitable inferences concerning contemporary treatment in other cases, a suggestion arises as to the special motive in these individual cases. The suggestion is that the victims were treated not so much for the wounds, which the skillless practitioner was unable properly to diagnose, as for the symptoms attending the lesions. Pursuing this suggestion, it appears that in every case the wounds were of such character as to produce coma, delirium, or other functional derangement so serious as completely to control the conduct of the individual—i. e., to produce in exaggerated degree such disorders as are habitually treated by the South Sea islanders. Assuming the treatment to have been actuated in this way, its localization, sometimes accurate but as often erratic, is easily understood; for no shaman is so completely dominated by his ideals as to neglect local indications. A parallel case in which



a gangrenous wound in the foot of an Indian was treated by incision through the flesh and scraping of the bone in order to extract a maleficent maggot has been recorded by Cushing.<sup>1</sup>

#### CLASSIFICATION OF PERUVIAN TREPHINING

On reviewing the foregoing evidence as to the culture-grade and antiquity of the Peruvian practitioners whose professional work is recorded in the Muñiz collection, it becomes clear that the instruments were chiefly or wholly of stone, and hence that the culture-grade was uncivilized; and since the use of metal quickly followed the Spanish invasion, it follows that the trephining must be considered prehistoric. This conclusion is sustained and established by the associations with the other products of Dr Muñiz' work.

On reviewing the evidence as to method, it appears that there is no indication of the use of differentiated instruments or of skillful procedure. It follows that the trephining must be regarded as primitive rather than specialized; and, since the operation is known from collateral evidence to have been performed in prehistoric times, it must be regarded as archaic.

On reviewing the indications of motive, it is found that the evidence is somewhat vague and illusive, yet, when considered comparatively, fairly satisfactory. There are suggestions of therapeutic treatment in a few of the crania, yet on the whole stronger indications that even in these cases the operations were thaumaturgic, while in the great majority of the specimens the operations can only be interpreted as wholly thaumaturgic; and, since there is nothing to indicate different culture-grades or differentiated methods, it seems necessary to conclude that all the operations belong to the earlier stage in the development of sophiology, and were essentially thaumaturgic. It is clear that most of the operations were ante-mortem, and there is nothing to indicate that any were post-mortem. At the same time there is, in several cases, conclusive evidence that the motive for the treatment was connected—albeit in a thaumaturgic way—with the individual treated,

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<sup>1</sup>This case is especially significant as an indication of theory and procedure in primitive surgery. The disorder was a tumor resulting from a local bruise, so advanced as to disorganize tissues and threaten general septicemia. The theory was that a "mysterious" maggot or worm, burrowing in flesh or bone, caused this disorder. The treatment was wholly thaumaturgic in plan, though partly (and incidentally) therapeutic in procedure. It began with the making of scalpels and lancets from bottle glass and obsidian, and with many incantations; next the tumor was cleansed; then a T-shape incision was made in such manner as to lay open the tumor, and the pus and serum were removed and the gangrenous tissue cut away, exposing the bone, with discolored periosteum, which was carefully scraped. At this stage a fetich, symbolizing the "mysterious" maggot, was laid in the wound and presently removed ceremoniously. Afterward the wound was repeatedly cleansed, sprayed with a red infusion of willow-root bark, and dried with scraped buckskin; finally the openings were stuffed and closed with piñon gum and neatly bandaged, the dressing being dusted with an astringent yellow powder. The infusion, gum, and powder were antiseptic, and combined with the excision of diseased tissue to effect a cure; yet the theory controlling the use of these substances was no more rational than the primary diagnosis: The red infusion symbolized healthy blood or vitality, the gum symbolized constructive process (in prescriptorial ideation), and the powder symbolized fructifying pollen. The complete cure was due partly to subsequent dieting, which was incidentally hygienic, though the design was, like that of the treatment, wholly symbolic or thaumaturgic. The bearing of this case on primitive trephining is manifest. ("A Case of Primitive Surgery," *Science*, N. S., vol. v, 1897.)



while there is not the slightest indication that the operation was vicarious in any case. Accordingly the motive must be subclassed as sortilegic.

#### SIGNIFICANCE OF PERUVIAN TREPHINING

As set forth on earlier pages, trephining began in early prehistoric times, and was performed after death for the purpose of obtaining amulets. It seems necessary to conclude that the operation was gradually extended to living captives for the same vicarious purpose, and it seems certain that the operation was extended in turn to others than captives for slightly modified yet still essentially vicarious purposes. On this part of the development of trephining the Peruvian specimens do not seem to bear directly.

As noted above incidentally, there is an important stage in the development of medical and surgical practice in which the motive is wholly thaumaturgic, yet in which the incantation is accompanied by medication or manipulation; and it may be added that there are numberless known instances in which the manipulation is of great severity, extending to scarification, penetration of the tissues, incision of the bone, and actual trephining. Sometimes the manipulation is beneficial, when the prestige of the shaman grows, and the aimless operation is thereby encouraged until, if frequently successful, it grows into empiricism, the forerunner of scientific medicine. There is thus a gradual transition from purely thaumaturgic manipulation into empiric surgery. Now, it would appear that the Peruvian trephining represents some stage in this transition; and nothing more than inspection of the ill-planned, clumsy, and extravagant cutting is required to show that the stage was early, and that the empiricism in which the pupil imitates the teacher and the son the sire could hardly have been reached. Accordingly, Peruvian trephining marks one of the stages in the development of this branch of medical treatment, and indeed of medical treatment in general; and it falls in place with the other known instances of primitive trephining, running from the vicarious operation of prehistoric times to the empiric operation of the present day, to illustrate and demonstrate the rise of the art of trephination.

As already noted, trephining is perhaps the boldest feature of modern surgery; and it may be characterized as the only feature of modern surgery which is known to be of great antiquity. Accordingly, trephining may be considered to represent the trunk of the genetic tree of surgery, and the history of trephining may fairly be considered to represent the history of surgery, at any rate until within recent decades; and this history demonstrates that at least the major operations of surgery were in the beginning performed on the dead, later on those whose lives were deemed worthless, and only in relatively modern periods for the alleviation of suffering and the prolongation of life. Thus the Peruvian collection is of special note as a record of an important period in the unwritten history of surgery.















